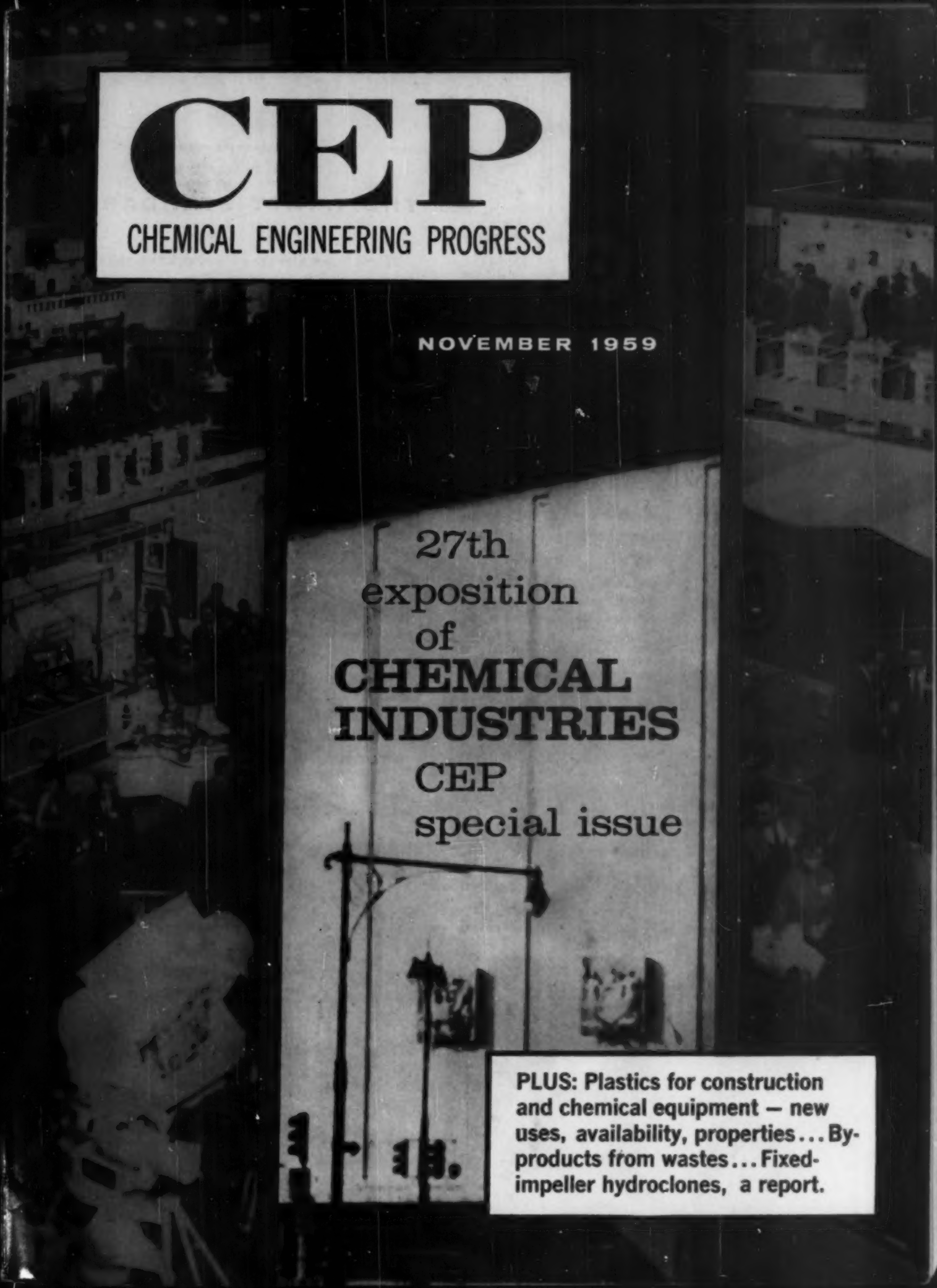

CEP

CHEMICAL ENGINEERING PROGRESS

NOVEMBER 1959

27th exposition of CHEMICAL INDUSTRIES CEP special issue

PLUS: Plastics for construction and chemical equipment — new uses, availability, properties . . . By-products from wastes . . . Fixed-impeller hydroclones, a report.

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CHEMICAL ENGINEERING PROGRESS
NOVEMBER 1959 Volume 55, No. 11

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Cover by Paul Arlt.

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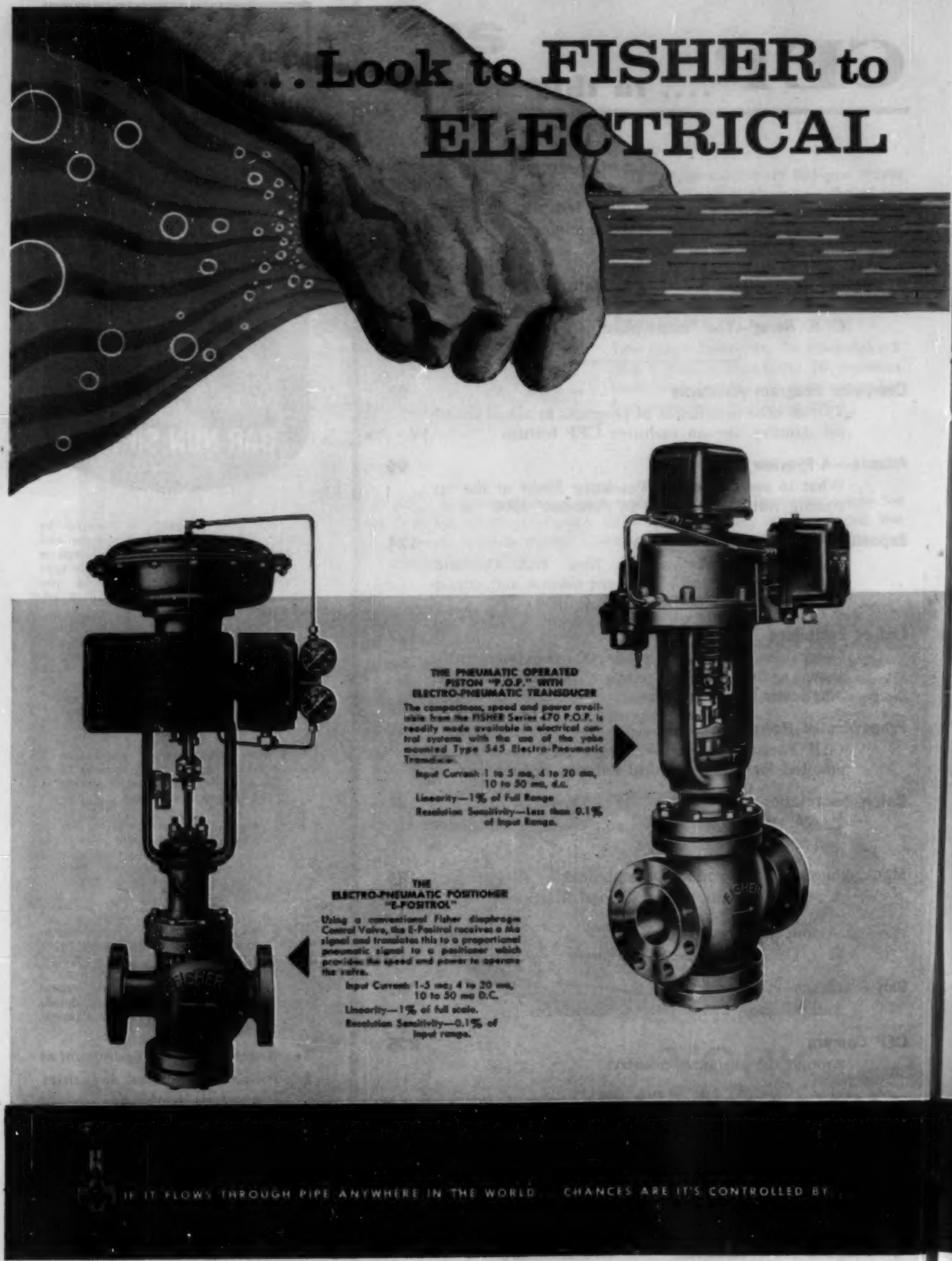
CEP .... in this issue

(Continued from page 3)

departmental features



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marginal notes

Applied statistics, thermodynamics, solid propellant compositions

APPLIED STATISTICS FOR ENGINEERS, William Volk, McGraw Hill Book Co., 1958, 354 p., $9.50.

Reviewed by Robert W. Kennard, Engineering Department, E. I. du Pont de Nemours and Company, Inc., Wilmington 98, Delaware.

In the preface the author states: "This book was written with three specific readers in mind: the engineer who has finished his formal training and who wishes to learn about the applications of statistics to industrial data; the engineer or technician who is interested in applying statistics to some specific problems; and the instructor in the engineering college who wants a text dealing with statistical techniques rather than theory."

It is unfortunate that one must recommend that all three readers seek another source for their needs in statistics. The text suffers from incorrect applications of statistical theory and contains incorrect paraphrases of statistical concepts.

One infers from the last statement quoted above, and from other statements in the text, that the author did not wish to include the more mathematical aspects of statistics. Most of the techniques that he discusses can be used without becoming acquainted with heavy mathematical machinery. However, regardless of the level of mathematics used, one cannot omit statistical theory. It is the theory that connects the technique with the live engineering situation. It is the theory that enables one to choose the proper method for a particular situation.

The intent of the author in developing his text around examples is to be commended. But there are two shortcomings. First, there are examples which are incorrect ones for the statistical theory to be elucidated. And secondly, there are cases in which the results appear to be inconsistent with engineering knowledge and judgment.

Example 7.11 is one instance where theory and engineering knowledge must be assessed in proper proportions. The data of this example consist of a series of 25 runs made at five temperatures and five durations to find the effect of these variables on the extent of conversion. The results are per cent conversion. "In order to see whether the different reactors and different operators had an effect on the results, the 25 runs were made in five reactors by five operators with the runs distributed among reactors and operators (so that the resulting arrangement is 5 x 5 Graeco-Latin Square)."

In this instance the author is in grave danger of providing another example of a classic miscue of the Graeco-Latin square in engineering analysis. From an engineering point of view there is no need for a formal statistical analysis to determine that there is an "effect" of temperature and duration. In fact, with a two-fold variation in temperature and a five-fold variation in duration considerable differences at conversion would be expected. This expectation is confirmed by an examination of the data which show percent conversions ranging from 15 to 100. In almost all such situations the aim of the experiment would be to obtain estimates of the type of effect that will take place, that is, the functional dependence of conversion on temperature and duration. The author does a disservice to his readers by omitting one very important assumption in the use of Latin Squares, namely, one must assume that temperature and duration of run are additive in their effects. In conversion problems this is surely the rare exception rather than the rule.

In connection with Example 7.11 one might also ask the author what advice he has to offer the reader who follows his suggestion for a "model 3" analysis and obtains predicted conversions greater than 100%. And finally one is led to question the values at 60 minutes and 120 minutes for 100°F. They seem to be inconsistent with the other data and may represent a transcription error or blunder of some sort.

Curve fitting principles and techniques are unquestionably among the important contributions that statistics makes to engineering analysis. However, the reader who follows procedures such as those used in Example 8.14 is headed for both trouble and disillusionment. The data of this example give the vapor-phase volume to the total volume ratio for different equilibrium pressures at 105°C for nitric acid. The data are plotted on both rectangular and log-log paper. "Both of these plots show marked deviation from linearity so that neither a . . . form $y = a + bx$ nor a form $y = ax^b$ can be expected to be completely satisfactory." An equation of the form $y = a + bx + cx^2$ is fitted. First, one will ask why a semi-log plot and fit was not tried. The equation $\log y = 0.052683 - 0.072653\ (P/100)$ gives a reasonable fit over the pressure range 200 to 1600 psi.

Secondly, every check indicates that the form $y = a + bx + cx^2$ is inadequate. The author finds that a term dx^3 should be added but settles for the quadratic "for the sake of simplicity, since it will account for 99 per cent of (the observed variation)." The square of the multiple correlation coefficient is, in general, a poor criterion to use in an absolute sense to judge the goodness of fit. The form is simple, but reasons should be given why the author is willing to settle for inadequacies such as the following:

The values predicted by this equation are off by 32% at 1600 psi. Likewise a plot of the differences between the observed values of y and the predicted values show a definite pattern that would indicate the fit can be improved. Furthermore the quadratic goes through a minimum at about 1460 psi — an impossibility for the phenomenon described.

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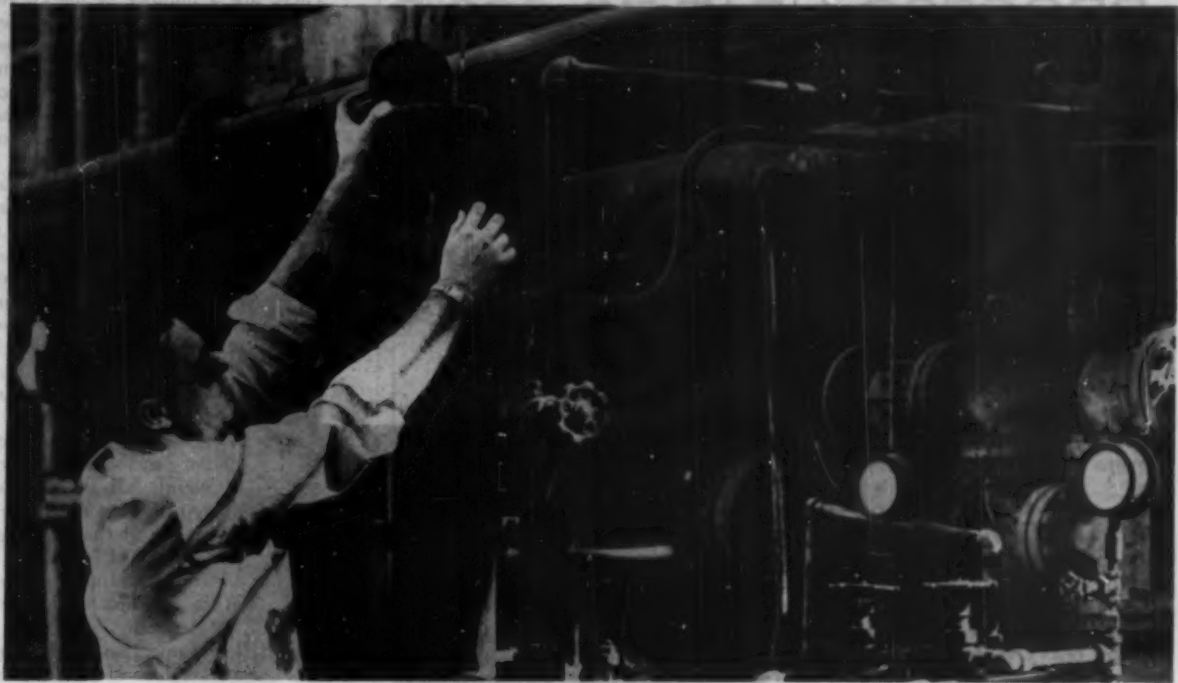

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marginal notes

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There are a number of inaccurate statements. Some serious examples are:

p. 224. "A correlation coefficient of 1.0 indicates a perfect association between the variables; a correlation coefficient of 0.0 indicates a completely random relation." The fact is, a correlation coefficient of 1.0 indicates perfect linear association. A correlation coefficient of 0.0 could occur with a well defined relationship, but one which would give a straight line with zero slope as the least squares line of best fit.

p. 110. "Ninety-five per cent of similar measurements of x would fall within the range of $x \pm ts(x)$, where t is taken at the 0.05 significance level." This is a common misinterpretation of the concepts of the confidence limit.

p. 158. In connection with one-way analysis of variance the statement is made . . . "(the between mean square) cannot be less than (the within mean square) since it is at least an estimate of σ^2." On the contrary, if the hypothesis being tested is true, we would expect to obtain a smaller value about half the time.

There are a number of misleading elements.

Figures 3.6, 3.7, and 4.1 use x, the sample mean when the population mean, m, is proper. The same is true for the standardized normal variate on p. 98 $z = |x - x|/\sigma$ which should have an m instead of an x.

The responsibility for the errors in statements of statistical theory and the apparent disregard of known engineering facts must rest with the editors as well as the author. It is difficult to believe that this text was reviewed prior to publication by either a chemical engineer or a statistician.

ENDLESS FRONTIERS, THE STORY OF McGRAW-HILL, Roger Burlingame, McGraw-Hill Book Co., New York, N. Y., 506 pages, $7.50.

The fiftieth anniversary of McGraw-Hill's Book Publishing Division was

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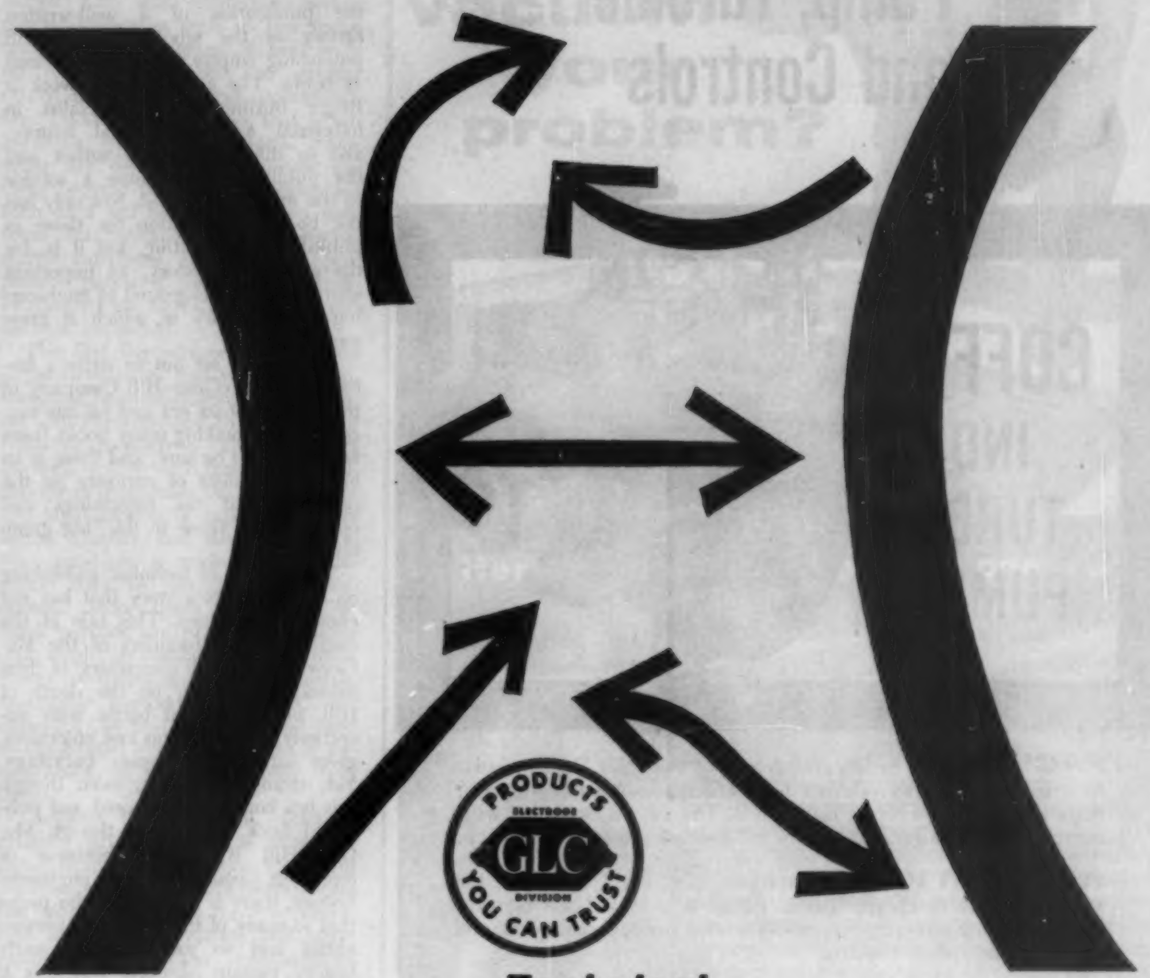
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marginal notes

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marked by a fitting commemoration—the publication of a well-written history of the whole McGraw-Hill publishing empire, magazines as well as books. The author of the work is Roger Burlingame, a specialist in industrial and commercial history, and in this volume the author and the publishers have done a service to the engineering field. Not only has the book a fascination for those in publishing and editing, but it is, for the student of history, an important source of the background of engineering in a century in which it grew mightily.

Burlingame set out to write a history of the McGraw-Hill Company in the context of its era and he has succeeded. "Of making many books there is no end," to be sure, and there is an immense amount of curiosity on the outside about the beginnings and operations of those in the "big green building."

The impact of technical publishing on the world is a story that has not enough champions. This tale of the courage of the founders of the McGraw and the Hill companies, of their subsequent merger on the death of Hill, of the eternal battle with advertisers, of the dreams and objectives, gives satisfying glimpses backstage. Yet, strangely enough, even though this is a company-sponsored and published book, and, even though McGraw-Hill is in the business of reporting contemporary engineers' history, there is a plaint in the pages that so many of the important personalities and so much of the early history remain obscure. But this is perhaps a tribute to those who worked so hard and so fast that they had neither opportunity nor inclination to report their day-to-day activities. All in all, this is a fine book for those interested in more than the data and formulas of engineering. F. J. V. A.

Solid Propellant and Exothermic Compositions, James Taylor, George Newnes, Ltd., London, England, 153 p., $4.25.

Reviewed by R. A. Cooley, exec. vice president, Propelbx Chemical Division, Chromalloy Corp.

Dr. Taylor of the Nobel Division Laboratories of Imperial Chemical Industries has spent some thirty years in developing explosive compositions as energy sources for various applications. His monograph is a valuable,

marginal notes

although brief, discussion of chemical compositions and designs of explosive actuated devices. It is concerned primarily with solid materials having special properties such as low flame temperature, liberation of heat with no formation of gas and greater safety in mine blasting operations. Dr. Taylor clearly shows that when materials with certain special properties are developed, ingenious devices become possible. His examples such as a self-heating soup-can may seem insignificant, but jet engine starter cartridges and one shot propellant powered devices for emergency uses on aircraft elsewhere can become important.

The first five chapters contain 64 pages devoted to Self-Sustained Exothermic Chemical Reactions, Gunpowder and Pyrotechnics, Explosives, and Initiating Explosives. These chapters are well written with concise generalizations ranging from the manufacture and legal aspects of explosives to reaction kinetics and flame structure. Very good use is made of thermodynamic data in the discussion presented. More space is devoted to black powder and mercury fulminate than might be justified from a United States viewpoint since these materials, especially mercury fulminate, are ceasing to be manufactured and used in the United States. The field of pyrotechnics is treated in only four pages.

Chapters 6, 7 and 10, although totaling only 36 pages, are quite welcome from the American viewpoint because relatively little information has been published in the open literature on guanidine nitrate and nitroguanidine propellant compositions and the British "Hydrox" blasting material.

Chapter 10 discusses about eighteen devices powered by propellant sources extending from submarine and stud driving guns used in salvaging operations to propellant starter systems for diesel and jet engines.

Chapters 8 and 9 on Rocket Motors and Solid Charges for Rockets and Propulsion are sound but short discussions covering 31 pages. The last chapter on Gasless Reactions is of an introductory nature.

Dr. Taylor is to be congratulated for writing a useful, brief account of a field not described in many books. The references at the end of each chapter are few in number but were well chosen.

This volume would be a good in-

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vestment for young technically trained personnel just entering this field or for more experienced engineers and scientists who want a concise description of it, particularly from the British viewpoint. The mechanical engineer will find that the book presents useful general information on the chemical aspects of materials he may need. Yet the book does not go into the chemical problems in great detail. The chemist or scientist may find the book worthwhile in that it describes chemical developments for a variety of constructive applications of explosive materials "ranging from the winning of coal to the dispersion of insecticides."

THERMODYNAMICS, Gordon J. Von Wyler, John Wiley & Sons, New York, N. Y., (1959), 567 p., $7.95.
Reviewed by Wayne C. Edmister, Oklahoma State University.

This is a well written book. The thorough and clear explanations should make a hit with teachers and students alike in undergraduate engineering thermodynamics courses.

The first half of the book (Chapters 1 thru 10) covers the usual thermo fundamentals, i.e., definitions, properties, work and heat, first and second laws, entropy, ideal gases, availability, irreversibility and efficiency. These topics are of interest to all engineers. This part of the book would have been improved, however, if the author had included real as well as ideal gas behavior and calculations.

Closed, open and *isolated* systems are defined in Chapter 2. The changing inventory open system is discussed in Appendix I under the heading of *Control Volume* but no illustrating examples are included.

The third quarter of the book (Chapters 11 thru 13) deals with heat power, refrigeration and fluid flow, applications that are mainly of interest to the mechanical engineers. These subjects are expertly treated.

Thermodynamic relations, equations of state and generalized charts are covered in Chapter 14 by a treatment that is probably adequate for mechanical engineering students. Chemical engineers would need more on these topics.

Combustion is covered in two excellent chapters (15 and 16), the first dealing with heats of combustion and entropy increases while the second is devoted to equilibrium between reactants and products of combustion reactions.


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Smog elimination—a progress report

It is now generally accepted that nitrogen oxides play a vital role in the photo-chemically-induced, smog-producing reactions occuring in the atmosphere. Primary source of these oxides is believed to be combustion processes of various types. In the Los Angeles atmosphere, for instance, it is estimated by the Air Pollution Foundation that 65 to 85% of the oxides come from burning gasoline in automobiles, while 15 to 35% originate from gas and fuel burning.

Feasibility of removing these oxides from automobile exhaust catalytically has been under investigation at the Franklin Institute, Philadelphia, under contract from the Air Pollution Foundation. Main line of research was the reduction of the nitric oxides to nitrogen by use of the CO and/or H_2 components in the presence of an appropriate catalyst. Discovery of an efficient catalyst, which could then be incorporated into a suitably designed auto muffler, would constitute a major step in smog elimination.

Zinc-copper chromite, iron chromite, barium-promoted copper chromite, and chromium-promoted iron oxides have been found efficient for removing nitrogen oxides in the presence of CO or, in some cases, in the presence of H_2, at temperatures of approximately 220 and 320°C. The Franklin Institute study also determined that chromites are efficient for inducing oxidation of hydrocarbons and CO, in the absence or presence of NO when sufficient O_2 is present.

Interesting angle in the research program was the use of actual samples of automobile exhaust, obtained from cruising cars. This was of course supplemented in some tests by synthetic mixtures of bottled gases.

Significant results were obtained by introduction of varying amount of O_2 into a stream of hydro-carbons-CO-NO-N_2. Maximum removal of NO, CO, and hydrocarbons (96% of NO, 96% of CO, and 70% of hydrocarbons) occurred when 3.56% O_2 was added to the stream. Since the O_2 content of automobile exhaust averages around 1.3% for idling, cruising, and acceleration, additional O_2 would have to be fed into the exhaust stream prior to its entry into the catalyst bed to effect the greatest removal of hydrocarbons and CO. However, no O_2 need be introduced into the system if it is desired to remove only NO.

Major industrial alcohols plant for Lake Charles

More than 50 million lb./yr. of production capacity for industrial alcohols has been scheduled for completion in early 1961 at Lake Charles, Louisiana, by Continental Oil. According to Lummus, engineer-contractors for the plant, a new technique, attributed to Karl Zeigler, will be used for the first time. Organometallic catalysts will be used to promote chain growth of ethylene; this will be followed by oxidation and hydrolysis to primary straight-chain alcohols containing an even number of carbon atoms. Ethylene, raw material for the new plant, will come from Petroleum Chemicals' Lake Charles facilities, in which Conoco owns a 50% interest.

And the desert shall bloom . . .

A new U. S. hospital in Tobruk, Libya, and the city of Zarzis in Southern Tunisia are to get saline water conversion plants of the electrodialysis type. The two installations will be financed by ICA, equipment designers and suppliers will be Ionics, Inc., Cambridge, Mass.

More maleic

Pittsburgh Coke & Chemical has approved plans for 20 million pounds of annual maleic acid capacity at its main Neville Island works. Start-up is set for early 1961.

Ilmenite in New Jersey

A "large" deposit of high-grade ilmenite ore in Ocean County, N. J. has been acquired by Glidden Co. The deposit is said to represent a 20-year supply of ore at the company's present level of operations. A concentrating and separating plant at the site is slated for completion late in 1961.

New editor takes over at CEP

CEP is taking this opportunity to introduce its new chief editor, Larry Resen. A chemical engineer with long experience in the field, as well as on the publication side, Larry takes over his new duties with this issue.

Larry, officially Frederick Lawrence Resen, obtained his B.S. in Chemical Engineering from the University of Colorado, Boulder, in 1950. His most recent position prior to joining *CEP* was Refining Editor of *The Oil and Gas Journal* in New York—a job he held about a year, having been transferred up from the Houston office where he was Gulf Coast District Editor for seven years plus. During these years he was closely associated with chemical engineers in the refining and petrochemical phases of the petroleum industry. As a member of the South Texas Section, A.I. Ch.E., he was active in committee work for the annual Fall meeting and, just prior to being transferred to New York, headed up the Publicity Committee.

Prior to joining *Oil and Gas Journal,* he was associated with Dow Corning Corporation, Midland, Michigan, working in the product development laboratories. Other industry jobs included summer stints in a plant control laboratory for Claiborne Gasoline Company.

A veteran of World War II, Larry served approximately five years in the U. S. Navy, and was discharged as a Chief Fire Controlman.

At the University of Colorado he participated in the student chapter of the Institute, was president of the student body, president of Tau Beta Pi, and editor of *The Colorado Engineer,* College of Engineering publication. He's a member of Sigma Tau, Pi Kappa Alpha social fraternity, and the Chemical Industry Association.

He resides in Wilton, Connecticut, with his wife, Margaret, a Houstonian, and son, John 3½.

Cyanamid to make laminated plastics in Italy

Cyanamid International is reported to have acquired facilities in Italy for production of laminated plastics. The move is said to be part of an expansion program abroad, including Britain, Germany, France, India, and Australia.

U. S. Cuban nickel interests in jeopardy?

The Castro Government in Cuba has indicated its intention of "investigating" concessions held by two American-owned nickel and cobalt plants in Cuba—Freeport Sulphur's Moa Bay development, and the older U. S. Government-owned Nicaro plant now operated by National Lead. "The Government's tendency would be for recovery of these riches," said Premier Castro in a recent television broadcast.

Nuclear saline water conversion plant

The Department of the Interior and AEC have signed an agreement for a cooperative project for development of a nuclear-powered saline water conversion plant. The unit will be a 400,000 thermal kilowatt, experimental, low-temperature process heat reactor, capable of producing saturated steam at pressures from 5 to 175 lb./sq.in.

SCOPE

continued

The engineering technician—in the middle again

"A sizeable segment of managerial personnel does not understand the proper place of the technician in industry," reports W. G. Torpey, consultant in the Office of Civil Defense Mobilization, Washington, D. C., summarizing the results of a study of technical institute curricula carried out by a task force of the President's Committee on Scientists and Engineers. Torpey spoke before the recent Missouri Conference on Utilization of Engineers and Scientists at the University of Missouri.

Purpose of the study was to review the content of technical institute curricula, to obtain opinions on their adequacy from employers and educators, and to make recommendations for improvement.

Main bottleneck in the effort to employ a larger number of technicians, and thus relieve engineers and scientists for more highly professional tasks, seems to be a distinct lack of agreement within industry as to the exact nature of the proper work of technicians. One Committee suggestion for improving management understanding is the use of work analysis studies to identify technicians' jobs—it is thought that the resulting identification may suggest up-grading of certain positions or employees to the professional level, and the downgrading of other positions or employees to an intermediate subprofessional level.

A second obstacle uncovered by the study is the reluctance of some supervisory scientists and engineers to accept the technician as a necessary, useful member of the technological team. Suggestions aimed at reducing this reluctance include establishment of in-plant training programs to orient professional supervisory personnel in the potential use of technicians, appropriation by management of sufficient funds to permit appointment of needed technicians, and use of incentives for scientists and engineers who, as supervisors, do make successful use of technicians.

Third difficulty, according to the Committee report, is the practice of considering the technician as an engineer-in-training. Thus, the technician's normal line of promotion may often seem to be through the engineering classification. It is strongly urged, however, that the advancement of the technician should be more properly considered within the framework of his own education and ability.

Further work is also needed in the accreditation field; survey results have proved that employers express particular satisfaction with those technicians who have graduated from accreditated schools.

Natural gas strike in Alaska

First commercial discovery of natural gas in Alaska has been reported by Union Oil of California, operator of a joint exploratory drilling program with Ohio Oil on the Kenai Peninsula, southwest of Anchorage.

International heat transfer research program

Research at Battelle Institute, under sponsorship of the Euratom-U. S. Joint Research and Development Board will stress heat transfer and vapor formation phenomena encountered in nuclear power reactors.

Petrochemicals take giant stride in Australia

With the awarding to Fluor International, of a contract for a $10 million synthetic rubber plant in Australia, another major step has been taken to implement a planned $50 million, four-plant complex for petrochemical production in Australia. The synthetic rubber unit, first in Australia, will be operated by Australian Synthetic Rubber Co., operations affiliate of Vacuum Oil Co. Pty, Ltd., itself a subsidiary of Standard-Vacuum Oil, White Plains, N. Y. The new plant, slated for start-up in 1961 at Altona, near Melbourne, will co-polymerize butadiene and styrene to produce 30,000 long tons of GRS rubber per year. Last June Vacuum Oil awarded a contract to Fluor-Utah Australia, Ltd., for the basic plant of the projected complex. This $28 million installation will process selected hydrocarbons from Stan-Vac's Altona refinery to supply butadiene to the synthetic rubber plant and ethylene to a styrene plant and to a polyethylene plant.

ECO ENGINEERING NEWS

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VOL. 1, NO. 6

Chemical Show EXTRA

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(continued on next page)

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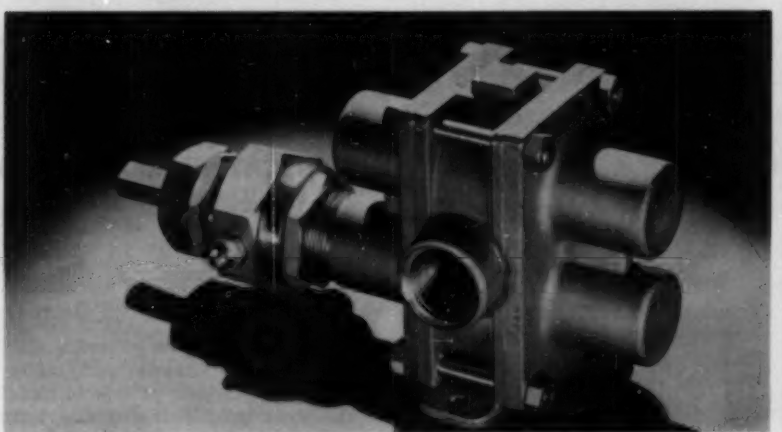
Impellers of TEFLON, phenolic plastic resins, Hypalon, Nylon, etc.

Capacities to 10 gpm, pressures to 100 psi.

Viscosities to 900 SSU and suitable for non-lubricating fluids.

Self-Priming with all non-volatile liquids.

Drives: direct 1750 rpm electric motor, air motor, pulley, sprocket and all conventional variable speed drives.



ECO GEARCHEM PUMPS

If you require self-priming and intermittent or sustained operation with constant flow metering and reproducible accuracy within plus or minus 1 percent, or maintenance of vacuum in the micron range—handling all commercial chemicals, acids, oxidants, alkalies, aromatics, solvents—select the Eco GEARCHEM Pump.

Housings of type 316 and Carpenter 20 stainless steel, Hastelloy C and B, monel, nickel, zirconium and titanium permitting the selection of the exact metal offering greatest compatibility with the specific chemical to be pumped.

Bearings of du Pont TEFLON and carbon.

Gears of chemically-impervious TEFLON, carbon, phenolic plastic resin, Nylon, Hastelloy C.

Capacities to 10 gpm, pressures to 100 psi. at speeds to 1750 rpm with light bodied media.

Viscosities to 30,000 SSU with metallic gears and reduced speeds and volumes.

Self-priming, even with volatile fluids.

Drives: direct 1750 rpm electric motor, air-motor, pulley, sprocket, flexible shaft and all conventional variable-speed drives.

Chemical Show EXTRA

See the pumps used in handling distilled and deionized water, preventing air entrainment and contamination in the pharmaceutical, photographic and electronics fields.

See the pumps handling liquid Sodium in paraffin oil for A.E.C. Installations.

See the pumps handling plastics with viscosities to 45,000 SSU.

New—Floating wear plate design Eco GEARCHEM pump is self-compensating for wear and thermal expansion and contraction, providing the same high metering accuracy (± 1 percent) at all temperatures from $-70°F$ to $+250°F$ and above, throughout a much longer useful life.

New—The famous Eco Factory Mutual Approved Stainless Steel Safety Dispensing Valve is now also available in the rare metal Titanium for corrosives outside the realm of the Stainless Steels.

New—The Eco GEAR-VAC Valve energizes flows of extremely high viscous media (up to 250,000 SSU)—a fluid "almost solid enough to walk upon" and dispenses them with positive metering accuracy in volumes up to 2 gpm. Revolutionary advantages: eliminates need for heating or pressurizing media, precludes sluggish, time-consuming gravity feed, offers linear flows as opposed to lumpy, spasmodic delivery.

See the pumps used in handling elusive mercury—bone dry, fourteen times heavier than water, a fugitive element extremely hard to contain in any stuffing box.

See the pumps which are maintaining vacuums in the 20 to 50 micron range in the high vacuum distillation of aromatics.

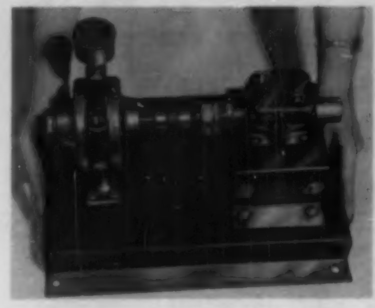
See the only positively non-contaminating pumping units offered industry, today.

See the laboratory pump that handles severe corrosives, round the clock—the ideal general purpose laboratory unit.

See the standard, stock, centrifugal pump that meets the standardization programs of major multi-plant chemical companies, today.

the big name in small pumps for the process industries

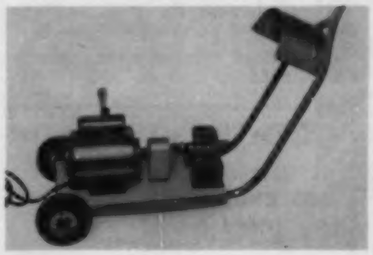
Ask, Also, About these ECO Specialties



Explosion-Proof Pump Units

For handling corrosive fluids under hazardous conditions, Eco Engineering Company has designed an explosion-proof packaged pump unit, incorporating air-motor drive. This unit is available for immediate delivery. It includes a variable speed air motor coupled with any one of Eco's ALL-CHEM corrosion-resistant rotary pumps.

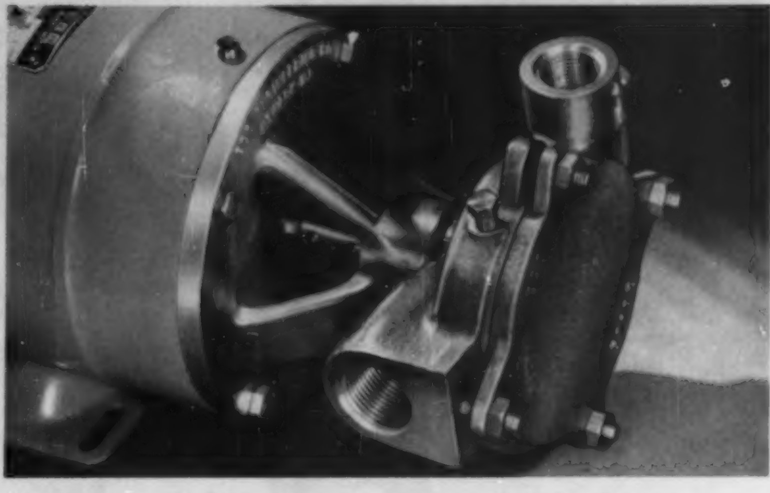
Pumpmobile



All Eco rotary and centrifugal pumps and drives are now available mounted on a portable, rubber-tired mobile unit. Measuring only 20 inches deep, the Pumpmobile is ideal for maneuverability in narrow quarters. Provides a rigid, vibration-free base and brings the pump to the point of use—wherever it may be in the plant.

TEFLON T-Film® Hydraulic Sealant

Eco's chemically-inert thread sealant and anti-seize compound for metal, plastic and carbon and ceramic systems and equipment, was produced originally as an aid to Eco pump users in the nuclear and corrosive chemical fields. After five years of highly successful use by the process industries, T-Film is now generally specified throughout chemical processing plants, wherever corrosives are encountered, and is regularly specified by the military services, the A.E.C. and their suppliers.



ECO CENTRI-CHEM PUMPS

The widely applicable, centrifugal, corrosive-resistant, chemical pump. Designed for standardization in multi-plant chemical corporations. Offered in two types—close-coupled motor mounting (illustrated) and ball-bearing pedestal mounting.

Material of Construction: Carpenter 20 stainless steel throughout—castings, shafts and impellers.

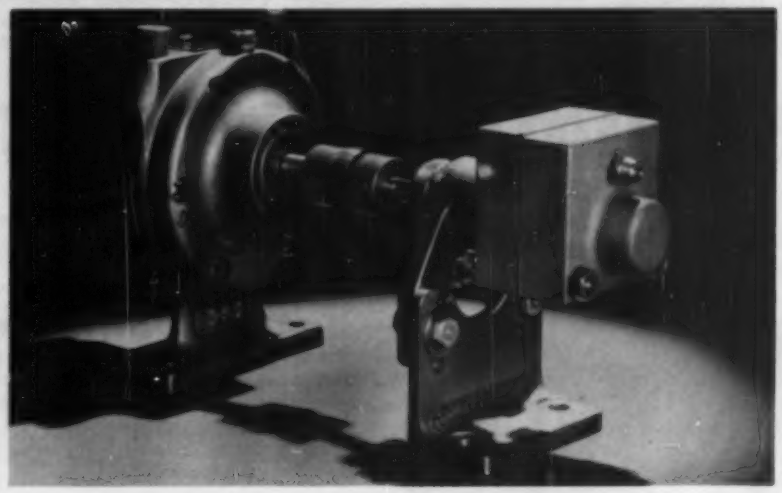
Impellers: Fully enclosed or semi-open designs available.

Rotary Mechanical Seal: Components to meet various corrosive exposures, range from TEFLON and ceramic, to carbon and ceramic, to carbon and Type 20 stainless steel or stellite.

Capacities to 40 gpm at 100 psi.

Face Plates: Standard are solid stainless steel. Pyrex alternates, permitting view of pumped media, available at no extra cost.

Accessibility: Impeller and mechanical seal may be readily inspected or removed without disconnecting pump from line.



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The ideal all-purpose laboratory and pilot plant units.

Capacities from 0 to 2 gpm.

Handle severe corrosives—'round the clock. Self-lubricated, non-contaminating.

Hastelloy C and TEFLON construction.

Non-contaminating, self-lubricated TEFLON bearings and seals.

Can be steam or chemically sterilized.

Yields a linear flow, best suited for constant flow metering.

Reversible. Self-priming.

Applicable for pressures up to 150 psi.

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New ECO DYNAMIC GEAR-VAC VALVES

A revolutionary development handling highly viscous media (up to 250,000 SSU).

Energizes flows of such media and dispenses them with positive metering accuracy in volumes up to 2 gpm.

To accomplish this, the GEARCHEM valve produces almost absolute vacuum, causing the viscous mass to collapse into the vacuum pocket, providing a constant supply in the gear chamber for positive pressure dispensing with reproducible metering accuracy within ±2 percent.

Linear, bubble-free flows, requiring no heating or pressurizing of media, in contrast with lumpy, spasmodic flows of plug valves, used in this same service. Spur gears permit reversing flow.

Manual or Motor Operated—with pulley, sprocket wheel or flexible shaft drive for remote or process controlled operation on constant or cyclic flows.

Other valuable, "extra-dividend" uses.

Simplicity of Design—Complete accessibility of all working parts without removal of valve from service. Standard 150 lb. 3 in. flange connection on suction side offers unimpaired flow of viscous media to valve.

New ECO DISPENSING VALVE

Now available in Titanium as well as Stainless Steel and Teflon.

• Factory Mutual Approved •

The rare metal, Titanium, ideal for critical services in atomic energy, electronic and chemical industry applications—offers outstanding resistance to many types of corrosive media, including some of the most troublesome industrial chemicals. Such media as nitric acid in all concentrations including white fuming nitric acid, solutions of chlorine, chlorinated organic compounds and inorganic chloride solutions, nitric-sulphuric acid mixtures and chlorinated hydrocarbons are among those handled.

The Titanium Valve utilizes the same proven fume-tight design with spring-loaded chemically-impervious TEFLON seals, that overcome seizure problems and assure instant, positive shut off or instant, full flow as desired. It eliminates dangerous after drip or leakage, putting to work outstanding safety features in the handling of some of the most hard-to-handle problem chemicals.

New ECO LITERATURE

- GEARCHEM PUMPS—SERIES 400
- GEARCHEM PUMPS—SERIES 700
- ALL-CHEM PUMPS—PP1M AND PP2M
- NEW ADDITIONS TO ECO LINE
- EXPLOSION PROOF PUMP UNITS
- MINILAB HCT ROTARY PUMP
- MULTI-PURPOSE BRONZE DISPLACEMENT PUMPS
- CENTRI-CHEM CENTRIFUGAL PUMPS
- T-FILM THREAD SEALING COMPOUND
- SAFETY CHEMICAL DISPENSING VALVES
- GEAR-VAC VALVES

Note: This is a regular issue of Eco Engineering News, published in the leading Chemical Processing Papers on the occasion of the 37th Exhibition of the Chemical Industries. If you would like to continue to receive this "What's New in small pumps and allied equipment" publication, through the mail, send your application on company letterhead.

All catalogs offered above are free on request.

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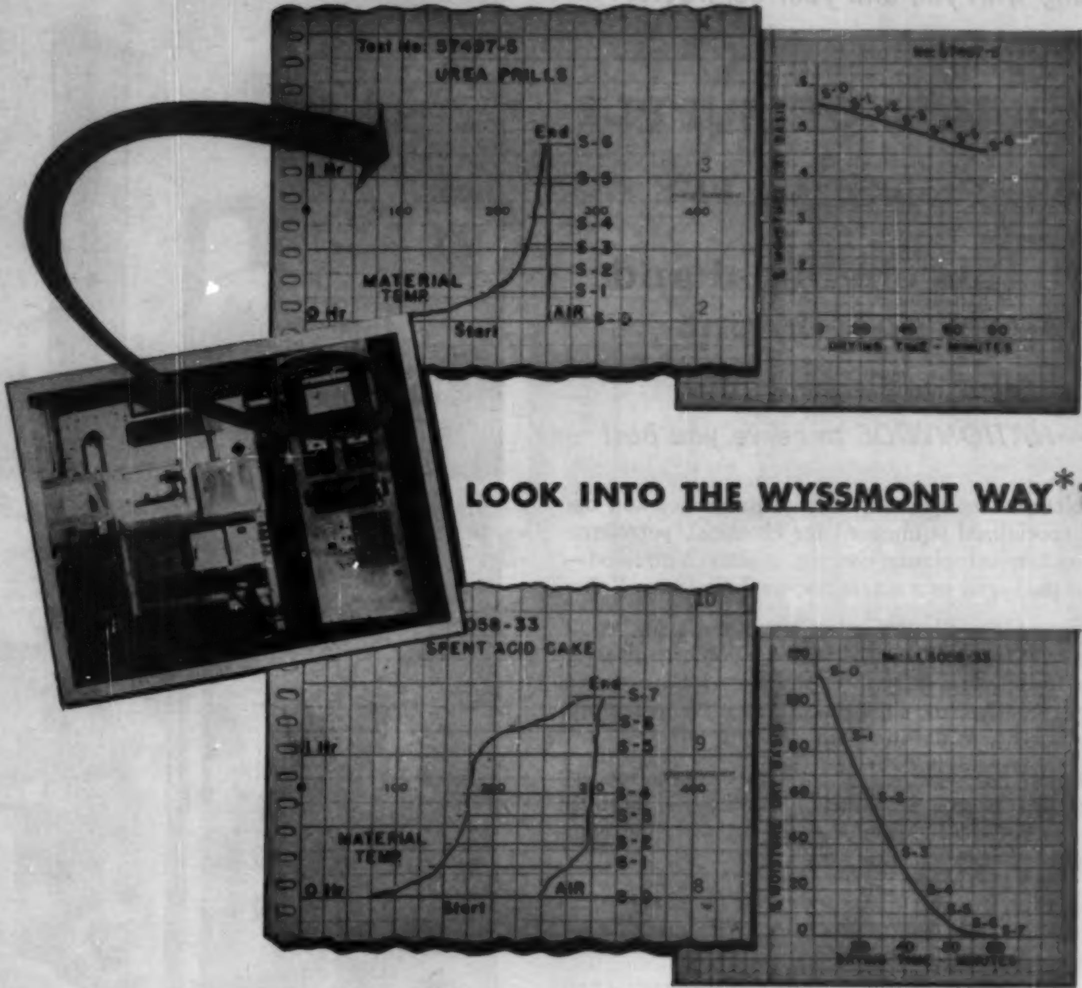

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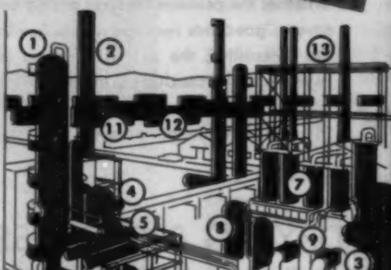

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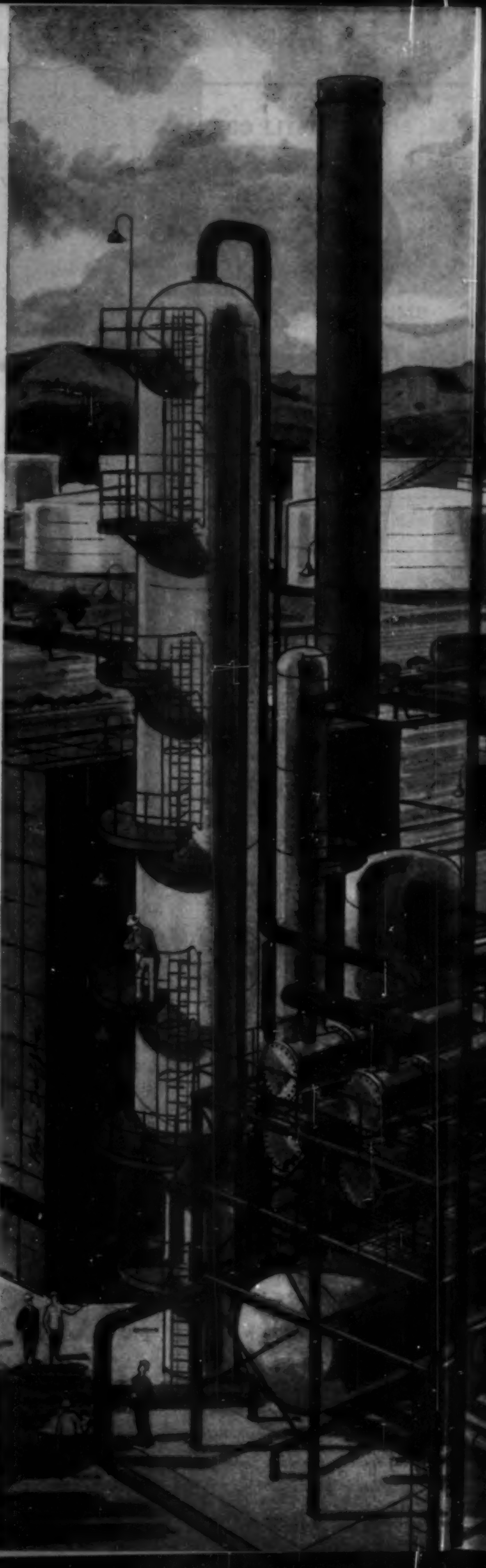

about our authors

Both **H. W. Schmidt** and **A. R. Gabel** are primarily interested in the field of coating and plastic development, and have done much work on it, particularly on evaluation of these materials. *Plastics for Corrosion Protection* is one result of their collaboration. They are connected with Dow Chemical, Midland, Michigan, in the materials engineering lab. Schmidt is director. Gabel, with the company over 20 years, is group leader in the lab.

C. H. Adams (*Engineering Properties of Plastics*) is manager of Plastic Product Development at Monsanto Chemical in St. Louis, Missouri.

A. E. Hoerl (*Optimization of Chemical Processes*) did the work on this paper independently, although his position at Du Pont ties in very well with the subject matter. He is supervisor, computional development, for the Wilmington, Delaware, firm. Hoerl has nearly ten years in this field, his

Authors Hoerl, Adams and Gabel

specialty. Possessing a BA in Mechanical Engineering and MA in Mathematics, our author is also editor of the mathematics section of the upcoming Fourth Edition of the *Chemical Engineers' Handbook*.

H. H. Sineath collaborated with **J. M. Della Valle** while he was at the experimental station at Georgia Tech as senior research engineer, on industrialized separation process studies. (*Operation Characteristics of Fixed Impeller Hydroclones*) is the result. Sineath also has worked on separation and extraction processes with International Mineral and Chemical. He is presently with American Viscose, Marcus Hook, Pa., as leader of film development. Della Valle, since deceased, was a member of the faculty at Georgia Tech. He had written hundreds of articles and held several patents, in his long career as researcher, teacher and author.

T. F. Anderson and **R. E. Barnett** (*Plastic Materials in Structural Applications*) are both with Haveg Industries. Barnett is plant manager at West Warren, Mass. and Anderson

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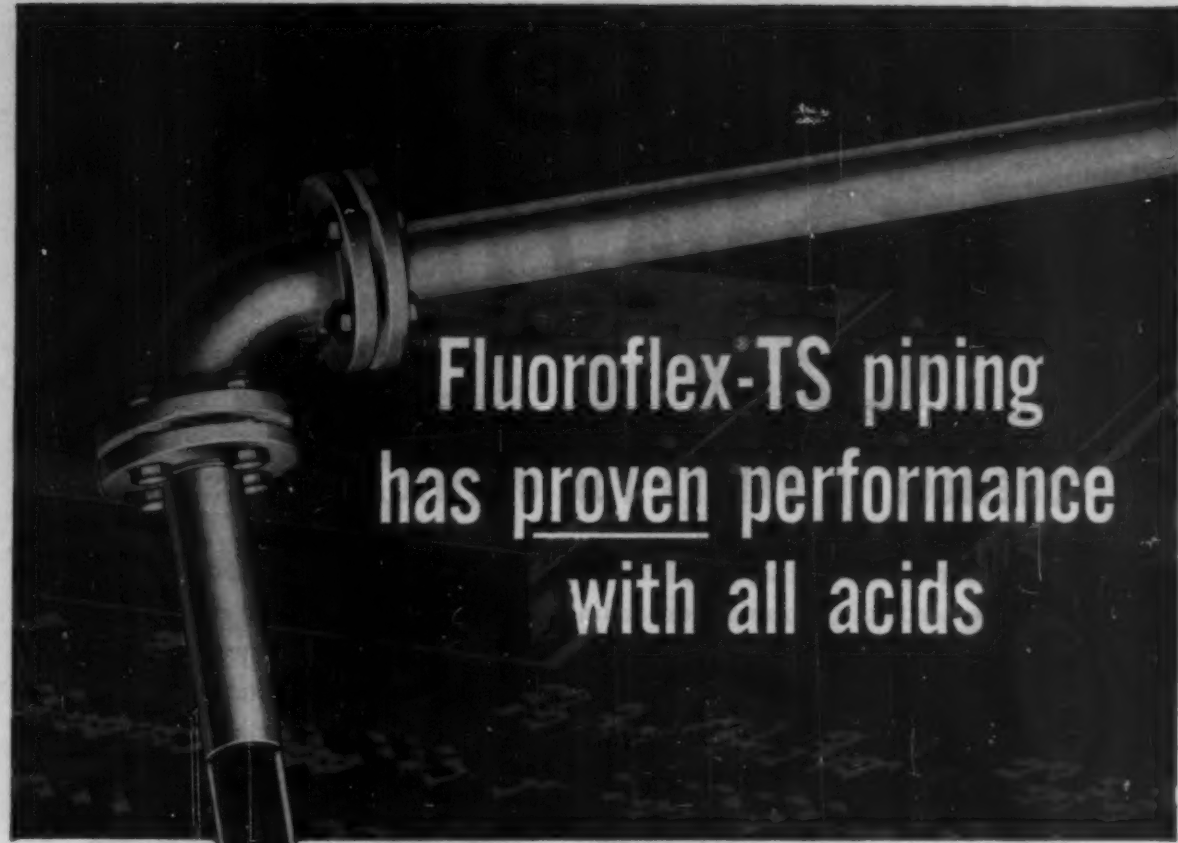

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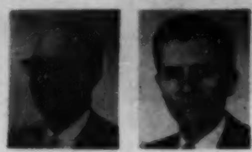
about our authors

from page 26

is director of research and development at Wilmington, Delaware.

C. S. Boruff (*By-product Recovery as a Pollution Control Measure in the Fermentation Industries*) has made many innovations in the distilling industry as head of the research staff at Hiram Walker. Result was profitable intraplant recovery of distillers feeds and riboflavin. Boruff was first associated with the Peoria, Illinois, company as chief research chemist early in 1934, and became technical director in 1937. He also has taught chemistry at his alma mater, Monmouth College.



Authors Boruff, Steffen

H. E. Atkinson (*Plastic Piping Systems for the Chemical Industry*) is in the materials and engineering department at Du Pont's Wilmington plant.

Alfred J. Steffen (*Control of Cleaning Wastes in the Food Industries*) has devoted most of his career to the problem of industrial wastes. Director of sanitary engineering at Wilson & Co., Chicago, since the end of World War II, Steffen was with the Wisconsin State Board of Health as a district sanitary engineer for several years. He also did a stint in the U. S. Army as an officer in the corps of engineers.

A carbon dioxide producing facility now being built by Chemetron's Cardox Division at Gibbstown, N.J. has a capacity of 155 tons of liquid and solid carbon per day. Raw material will come from Du Pont's nearby ammonia plant. Output distribution will be in liquid and dry ice forms to various industries on the east coast.

In Finland a chlorine and caustic soda plant just went onstream, using 50,000 amp. Uhde mercury cells furnished by a West German firm. The company is functioning at half capacity, expects to be in full production early next year. The company, Oulu Osakeyhtiö, is located at Oulu, at the northern extremity of the Gulf of Bothnia.

For more information, circle No. 98 ➤

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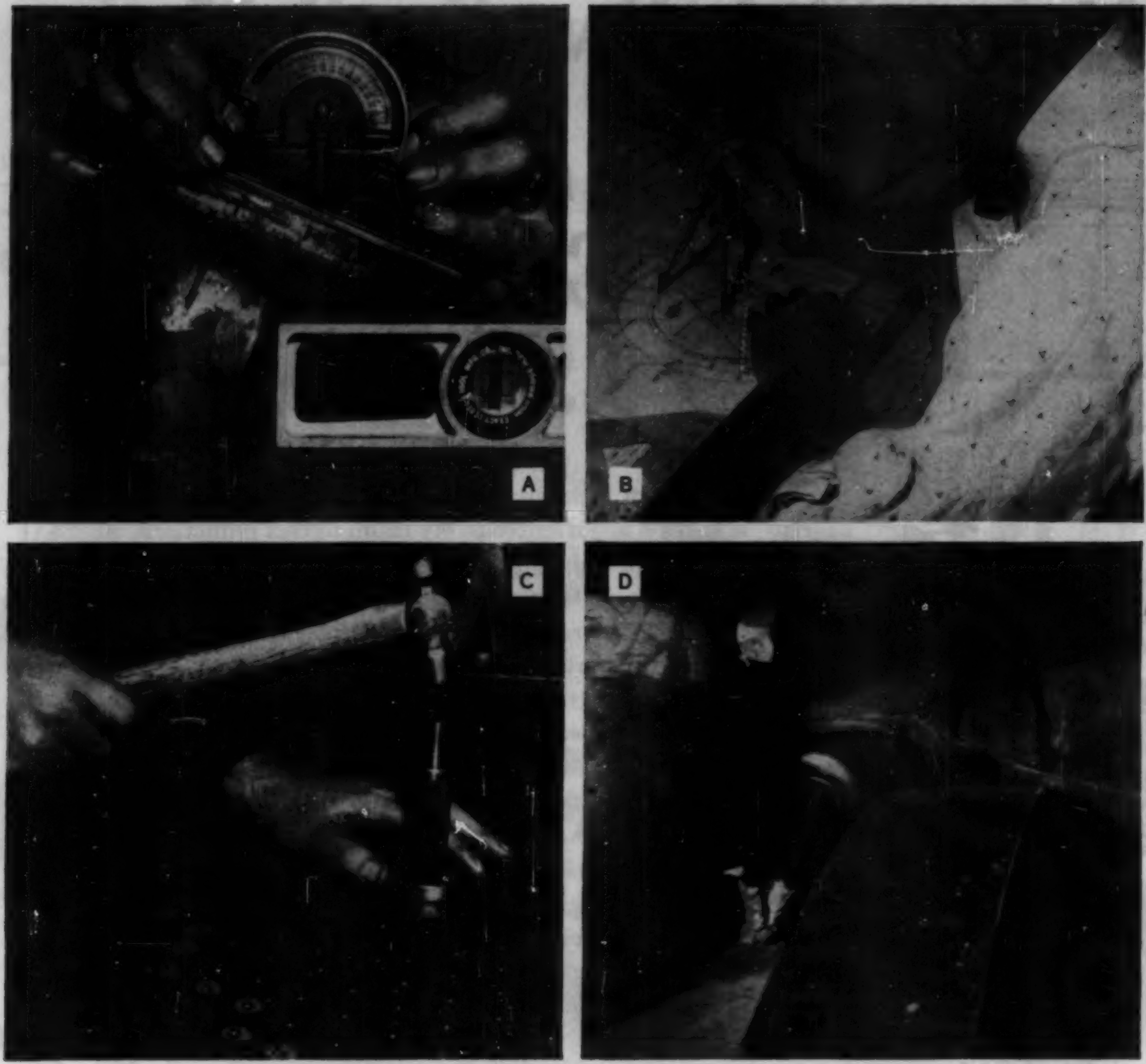

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For more information, turn to Data Service card, circle No. 13

Polypropylene grows—not without pains

THE POLYPROPYLENE PRODUCERS are making sure they won't be tagged with any "too little, too late" slogan. In fact, they're flirting with a "too much, too soon" label. With Dow jumping on the bandwagon with a West Coast plant being planned, and Montecatini raising its sights on the capacity of its previously announced West Virginia plant, total U.S. capacity on-stream in 1961 should total about 135 million pounds a year.

The all-important consumption figure, unfortunately, is expected to lag the capacity figure by a significant amount. In a recently made study Spencer's M. B. Stringfellow anticipated a 1960 consumption figure close to 30 million pounds. If this is doubled by 1961, the industry would still be producing at a rate less than half the installed capacity. Stringfellow also projected figures for 1963--the end of polypropylene's first five commercial years in the U.S.–when he looked for an annual consumption of 147 million pounds plus an additional 15 million in fibers. While this would easily soak up the present planned capacity, it's highly unlikely that the status quo will prevail until then and it's a pretty good bet that 1963 will find capacity increased so as to lead demand by a healthy margin.

That 147 million per year consumption figure would mean that polypropylene would have the fastest initial growth rate of any plastic going. Even conventional polyethylene, whose introduction was retarded by the war, would have taken five years under ideal conditions to crack the 100 million mark. Linear polyethylene, which held the title of fastest growing plastic, won't be consumed at the 100 million pound per year rate until next year, which will mean it took 4-5 years to reach this level.

The dramatic introduction of polypropylene and the "boom" aspects of its growth have led some industry observers to wonder aloud if the bullish outlook isn't a bit on the optimistic side. They are all too cognizant of present high-density polyethylene plants limping along at less than 50% of capacity, a level not conducive to profit-making. This surplus capacity, in fact, has been soaked up to a degree by conversion to polypropylene production in a few instances. Technical limitations have to be overcome before the polymer can get wider acceptance they aver. For instance, the wet or clammy feeling of the film is a psychological disadvantage. Additionally, the producers cannot look to the export market to any great extent for the Montecatini interests have licensed several plants abroad and additionally have announced their intention to sell their product in the European market at about half the U.S. market price. Drawbacks such as these, however, do not preclude a substantial growth of the polymer these same observers are quick to note. They agree the technical limitations will sooner or later be overcome by R&D work and that the inherent properties of the polymer makes it quite an attractive product. They just wonder if a more moderate growth rate might be more to be expected.

The optimists are not to be discouraged and some point to a possible billion pound per year consumption by the end of 1965. They point to its fine acceptance to date and its ability to step into a void other plastics can't fill because of physical or chemical limitations. Only a small fraction of its potential uses have been explored they say and as these are looked into its usage will grow. And most importantly they say, it can be spun into fibers, an advantage not enjoyed by polyethylene.

An interesting sidelight has been the slowness of major polyethylene producers to get into the act. Excluding pilot plant and semi-works operations, five companies are due to produce the polymer commercially–Humble, Hercules, AviSun, Montecatini, and Dow. Only the latter is a major polyethylene producer. Notable by their absence are DuPont, Union Carbide and National Petro-Chem, which are the three largest polyethlene producers in the country. No great significance can be attached to this for when the time is ripe all three could jump into the swim quite easily with their knowhow; the former two are in position to convert low pressure units to polypropylene operation if desired. The only real point perhaps is that barring any great breakthrough, there's no percentage in contributing to an existing surplus of capacity.

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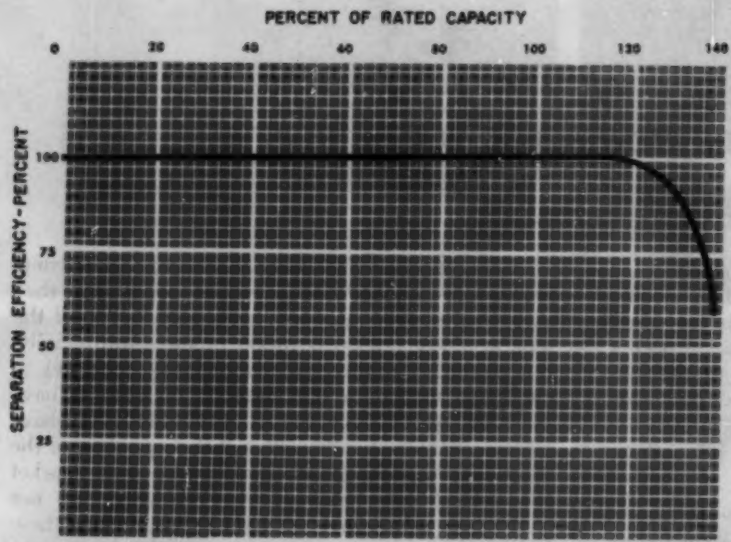
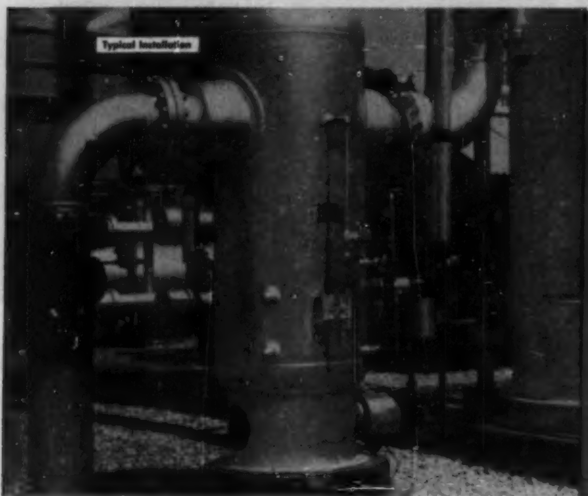


...with Peerless Separators you can remove entrained liquids from process vapor lines and maintain a high efficiency over the entire range of flow.



The above illustration shows a top view looking down at two of the many internal separator baffles. Entrained liquid droplets are caught in the pockets and drained down out of the gas flow . . . thereby completely stripping the gas before it leaves the mist extractor.

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PEERLESS MANUFACTURING COMPANY

P.O. Box 13165 Dallas, Texas

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- **Vane units can be made easily removable.**
- **Mist extractor and vessel can be made of any type material. Carbon steel mist extractors can be placed in a vessel and stress relieved without damage.**
- **Can be designed for any capacity or special requirement.**

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For more information, turn to Data Service card, circle No. 21

opinion and comment

Solving Tomorrow's Problems Today

May we predict something? Chemical engineering enrollments will be down again. We haven't received official figures, but we suspect that, when the results are all in, chemical engineering enrollments will be found to have dropped—just as they did last year.

We base our prediction not on a formal survey but on conversations with deans and professors in several institutions. We were told in one school that over half of the junior class identifiable as potential chemical engineers had switched to electrical engineering. The reason probably is the same as that offered by another head of a chemical engineering department—namely, that the glamour field of electronics is luring many students who are choosing engineering, while "science" is attracting students who normally would have followed an engineering curriculum and who, talents considered, would have greater success and satisfaction as engineers than as scientists.

Perhaps we are just borrowing trouble; perhaps when the figures are in we shall be proved wrong in our prognostication. Perhaps, too, the trend toward or away from the various engineering disciplines is, as many believe, self-regulating. When the demand for chemical engineers increases, the freshmen will perhaps again be attracted to the curriculum, or chemical engineering will regain those who have left it for other fields.

This supply-and-demand philosophy has always been the A.I.Ch.E. policy, for at no time has it beaten the drum for *more* chemical engineers. During the years of all the talk about the big engineering shortage, A.I.Ch.E. emphasized the need for quality in chemical engineering, and we do not in this editorial propose abandonment of this position.

This position, however, does not indicate indifference. The Institute is well aware that a live profession connotes not one, but two factors. The first, indeed, is quality. It has been the boast of chemical engineering educators for these many years that the better students—the "quality" students—were attracted by the challenge of chemical engineering. The majority of the best on campus could always be counted on to be in the chemical engineering curriculum. Today, one educator told us, this is not so. The challenge attracting young people is not chemical engineering; it is not the chemical field. It is physics, it is space, it is the atom.

The second implication concerns the coming "population explosion." Economists predict that in the late 1960's the gross national product must rise from its present 460 billion to about 700 billion. For this, the nation must train enough engineers and chemists in the early 1960's to take up the administrative and production tasks that such a gross national product will impose.

The need, in short, is for a guarantee that a satisfactory supply of quality students is continually attracted to chemical engineering. Of all the fields that have a challenge, chemical engineering is pre-eminent. If it is not now getting the top men on campus, that is only because the true romance and challenge of the chemical field are not being presented properly—and that is the fault of the chemical industry and the professional chemical organizations.

F.J.V.A.

For more information, turn to Data Service card, circle No. 72

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NOVEMBER **CEP** 1959
FEATURE

Plastics for corrosion protection

in the chemical industry

With proper selection, plastics often offer an economical solution to many corrosion problems. Advances in plastic technology in the past few years have produced materials with the physical properties necessary for materials of construction. Unfortunately, it is all too easy to make a poor choice when selecting a plastic for corrosion control.

It is difficult to select a plastic from handbook-tables as is done in the case of metals. Such tables are in the process of being formulated. However, with the great number of new plastic materials being marketed every year, and with the wide variation that can be obtained in physical properties with small additions of modifiers, an up-to-date listing is virtually impossible. This means that an engineer must have a good knowledge of plastics, and know the general characteristics of each generic type. After a specific type of plastic has been chosen, it would, in most cases, be wise to contact a manufacturer of that material and request a recommendation for the specific job in question.

There have been cases where this apparently safe method of procedure has been followed and yet failures have been experienced. Unsatisfactory results can sometimes be avoided by running chemical resistance tests in the laboratory previous to making any installation. Such tests will determine if any impurities present will affect the plastic. Particular attention should be given to the published heat resistance of the plastic and a wide safety factor allowed in this respect. This precaution is vital since it is more than possible that the published physical data will have been determined under static conditions and actual service conditions of heat and pressure may be more severe.

It is interesting to note that the United States is far behind several foreign countries in applying plastics in corrosion control. This can be attributed in some cases to the necessity for replacing critical metals during the war with plastic substitutes. But in many cases when new plants have been built since the war, particularly in Germany, many items have been specified in plastic on the basis of merit alone. At present, we in the United States have to depend to some extent on the experience accumulated in countries abroad to make the right choice when designing plants at home.

There is evidence that the United States is fast realizing the advantages to be gained by the use of organics over metals in many fields. For instance, the acquisition of plastic pipe

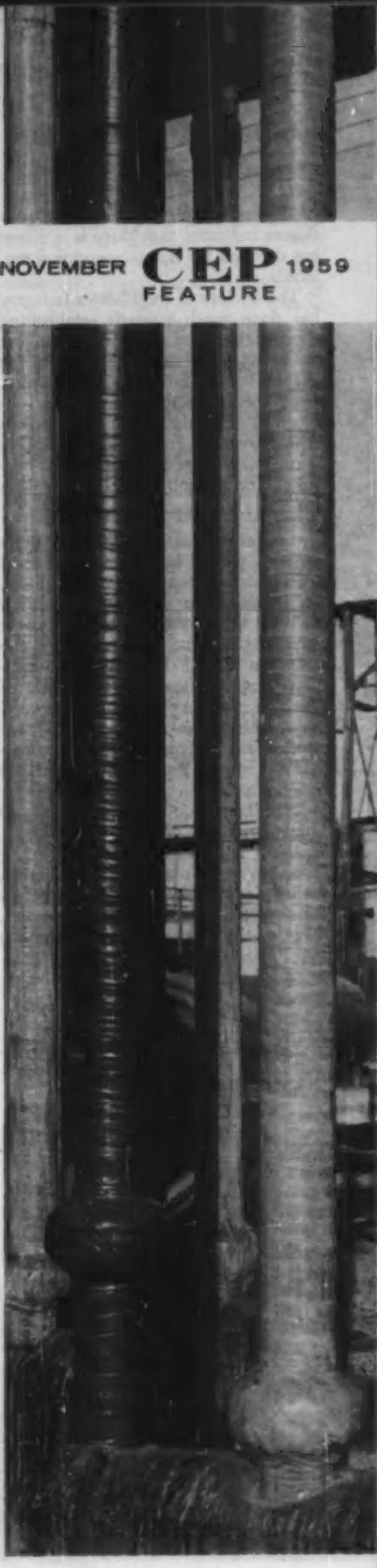

Figure 1. Conduit covered with epoxy glass laminate.

producing facilities by large steel producers indicates that there is a growing demand for non-conventional materials.

The Society of the Plastics Industry has done much towards establishing specifications and data that will allow the selection of the right material for a specific job, but it will be several years before standardization is accomplished. This means that considerable working knowledge of plastics is necessary to select the material best suited for the job.

Plastic types available

Assuming that the correct generic type of plastic has been established for resistance to a corrosive chemical, an investigation should be made as to what forms of fabricated stock are available. In the case of pipe, the selection would be limited to (1) glass cloth laminated with plastic of the thermosetting type, (2) extruded stock encased in steel pipe, (3) extruded stock which would be available in several types of thermoplastic materials.

The first case is limited to two generic types of plastics, namely, epoxies and polyesters. The epoxy type of pipe is more readily available, being manufactured by two companies in sizes from two to thirty-six inches. Due to the mechanical structure, the bursting strength and temperature limits are much greater for the laminated thermoset plastics. This results in broader application of this type of material. Encased plastic pipe is limited only by temperature and chemical resistance.

Economically, extruded plastic pipe would be the choice over the other two types described; and a good engineer will ask to what extent extruded pipe may be used in chemical plants.

The possibility should not be overlooked of using extruded pipe anywhere it will do a job in reducing corrosion and costs. Such applications as buried waste lines, brine transmission lines, and cooling water lines, all would be possible applications where thermoplastics could do a cheaper and better job. One possibility that is being considered is that of having portable extrusion equipment manufacture pipe in continuous lengths on the job site. On underground transmission lines the possibilities of savings are tremendous from such an operation.

There are certain processes that can utilize extruded pipe such as rigid polyvinyl chloride throughout, but a careful examination of the maximum temperature liable to be encountered must be made. This will include, of course, any localized areas that might be subject to a radiant source of heat.

Although the temperature limits on materials such as rigid PVC have been rising, an occasional failure has been experienced when the engineering was done without due regard for the limits that must be observed for thermoplastic materials.

It is of interest to note the extensive use of PVC pipe in a high surface area silica plant that was purchased in Germany and installed as a unit in this country. The piping conveys silica, air, and HCl. The temperature is approximately 100°F, and there have been no signs of failure during the five years it has been in service.

Most chemical engineers have on occasion investigated the possibility of using some plastic material in a process design, and have been deterred from specifying such a material because the apparent advantages were not enough to justify the additional cost of the installation.

There is a possibility of overlooking a potential savings by allowing the high comparative material costs to be the reason for rejecting plastics from further consideration.

Such a situation occurred when three wooden vent stacks were being carefully considered for replacement with laminated polyester stacks. The life of a wood stack was considered to be three years. The material costs amounted to $885 each. A polyester stack supplied in flanged sections cost $2100. There was no way of determining a possible life span in this particular service, and at first glance the economics were in favor of continuing with the wooden stacks.

A second look changed the econom-

Typical chemical industry applications of plastic materials now readily available

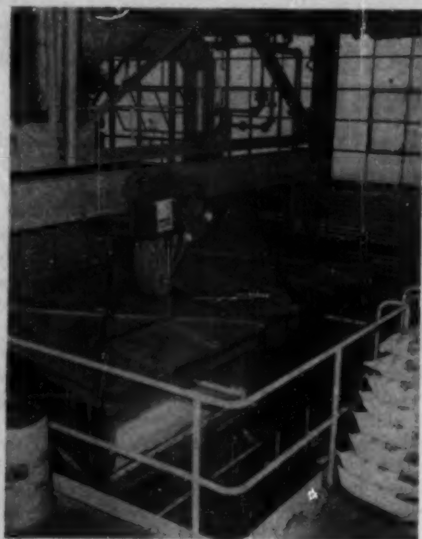

Figure 2. Rigid PVC fume hoods and ducts.

Figure 3. Plastisol coated ventilators for carrying acid fumes.

ics to favor the polyester stacks when it was discovered that the installation costs of erecting a wooden stack were $3000. Scaffolding had to be built for the full height of the stack which, with the large amount of labor in assembly, made installation costs the expensive part of the job.

The polyester stack was assembled on the ground and erected as a unit with a crane at a cost of $300. Not only was there a saving of $1,485 per stack on initial costs, but examination after two years service indicated a life expectancy of at least double that of the wood stacks. As an extra bonus, maintenance on the polyester stacks has been nil, while maintenance on the wooden stacks amounted to several hundred dollars every year.

It is possible that the performance of a laminated epoxy could be equal in all respects to the polyester used in this application. The epoxy resins are versatile in so many applications connected with corrosion control that it seems worthwhile to describe in detail some applications that have or are being made at present.

Epoxy resins

Epoxy resins may be hardened by the use of many types of catalysts. A common hardener is diethylene triamine which will react with the epoxy resin to give a strong chemical resistant plastic. By using a system of glass cloth and this plastic in alternate layers, it is possible to repair corroded sections of tanks, build complete vessels, or completely line existing tanks for protection against corrosive chemicals.

A series of 4-in. vertical, conduit-carrying, underground cables from a powerhouse to transmission lines is an example of plastics being used to prolong the useful life of an expensive installation (Figure 1). The conduit, which was exposed, developed holes from corrosion, and to avoid shorting from moisture it was necessary to replace or repair the conduit. To replace the conduit would involve a power shutdown which would have been expensive, plus a minimum cost of $15,000 for doing the job. The cost of applying a laminated epoxy system over the existing conduit was estimated at $2400. This system is intended to provide perfect protection for a minimum of ten years which makes the investment desirable.

In a process where hydrochloric acid is used, and where iron cannot be tolerated in any amount, coagulation trays have been built from epoxy-glass cloth laminate. The cost is comparable to Monel metal, which could not be used, however, because of contamination.

One company has made, and had on test for two years, a 200-bbl. self-supporting tank made in the same manner. This tank has been filled with concentrated hydrochloric acid during this period with no apparent deterioration. Certain epoxy resins have been used to protect steel storage tanks from the effects of 73% caustic at 250°F.

A casting type of epoxy resin has been used to fabricate a pump block to replace soapstone (Figure 4). Although the pump has not been in use over a long period, service to date is completely satisfactory.

Ferric chloride solution at 80°C presented a problem—no pipe that would last more than six months having been found. This temperature indicated a thermoset type of plastic and, of course, one which was resistant to strong hydrochloric acid. An epoxy-glass laminated pipe was installed, and all indications are that indefinite service will be experienced.

Some other areas where plastics may be profitably used in corrosion control are: ventilator hoods, fume hoods, window walls, roofing flashing, stair tread coverings, and liners for steel drums.

Plastisols

A plastisol is a dispersion of finely divided polyvinyl chloride in a plasticizer. Upon heating, a continuous film is formed which is resistant to many chemicals. In areas where acid exposures are severe, plastisols have been found effective in preventing corrosion on stair tread and floor gratings. Good results have also been experienced when ventilators carrying acid fumes have been coated with plastisols (Figure 3).

By replacing sections of steel window sash with polyester transparent wall panels, maintenance costs have been decreased to an insignificant figure.

In a process where dense acid fumes are encountered, complete hoods and ducts have been fabricated from rigid PVC and given exceptional service (Figure 2).

The problem of roof flashing deteriorating from chemical attack has been solved by using vinylidene chloride copolymer. This product can easily be made to conform to irregular contours, and can be cemented to all types of surfaces.

While plastics will reduce costs, provide superior materials of construction, and open new fields in the design of chemical plants, these advantages are possible only if the right material is selected for the job. Most manufacturers are anxious to have their product used but not misused, and capable technical help is available for the asking. #

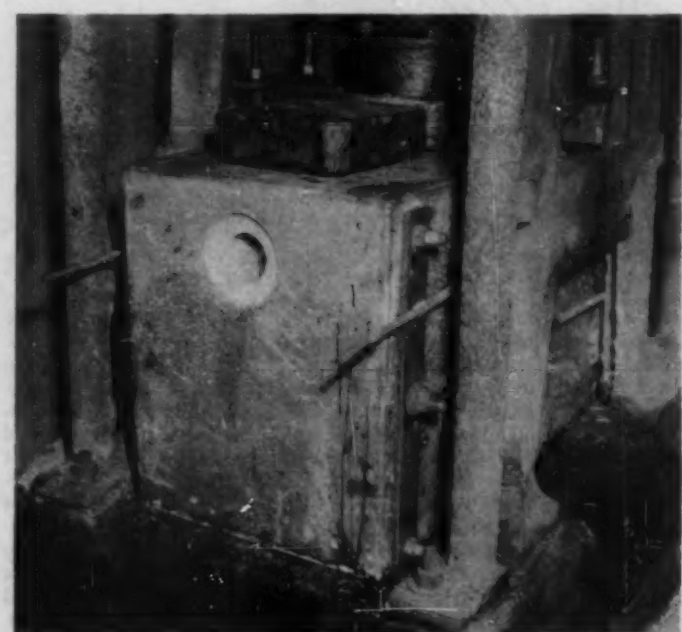

Figure 4. Cast epoxy pump block to replace soapstone.

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Engineering properties of plastics

The many chemical and molecular combinations attainable in high polymers, the base materials for plastics, make possible what is probably the broadest property spectrum of any of the engineering materials.

Molecular architecture

Giant molecules (plastics) derive many of their physical and chemical characteristics from their simplest repeating chemical structural unit, or basic building block, sometimes called the *mer*. The number of mers and their structural relationship in the polymer also contribute to the properties of a plastic. In varying degrees the basic unit of the polymer molecule governs its chemical resistance, flammability, heat stability, and electrical nature, Table 1.

The differences between high-molecular-weight polymeric materials and low-molecular-weight materials in a given chemical family are largely physical. For example: ethylene, mol. wt. 28, is a gas; polyethylene, by the high pressure route, mol. wt. about 20,000, is a soft, flexible plastic. Molecular size, shape, and structure differences rather than carbon-hydrogen analysis separate the gas from the plastic.

Perhaps the most important parameter affecting the physical nature of a high polymer is its molecular weight; often expressed as degree of polymerization, *i.e.*, number of mers in the chain, which is directly related to M_n, number-average molecular weight. The size of the giant molecule is also given in terms of M_w, weight-average molecular weight. During the course of a polymerization, the chains grow at varying rates and to varying sizes. Polymer molecular weights reported in the literature, therefore, are only indicative of average molecular size. Molecular-weight dependent properties include softening point, strength, melt flow, and solution viscosity. The generalized curves of Figure 1 show strength properties increasing rapidly with molecular weight to a plateau where large increases in molecular weight give rise to small increases in strength (*1*). In contrast, melt flow shows a constant decrease with increasing molecular weight.

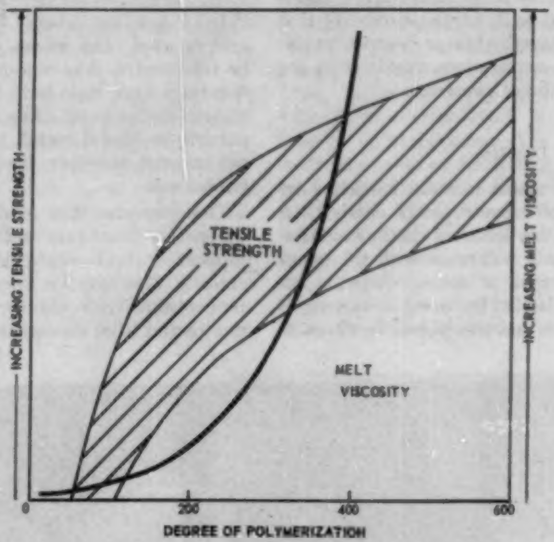

Figure 1. Generalized relationship—degree of polymerization vs. tensile strength and melt viscosity.

The M_n and M_w averages expressed as a ratio of M_w/M_n provide a guide to molecular weight distribution. When all of the molecules are the same size (this has yet to be achieved) $M_w = M_n$ and the ratio $= 1$. The relationship between properties and molecular weight distribution has yet to be investigated completely. However, it is known that the presence of small quantities of low-molecular-weight material lowers tensile strength, makes the polymer more susceptible to chemical attack, and has a plasticizing or softening effect. The geometrical relationship of the mer units in the polymer chain pro-

vides the chemist with another parameter in his property-oriented research. In Figure 2, several basic structures common to giant molecules.

Typical good fiber formers are linear polymers, the chains of which are readily oriented, a factor in optimizing the level of crystallinity. In addition, a high order of chemical and geometrical symmetry is needed in the chain if maximum crystallinity (therefore, strength) is to be realized. A strong fiber material is also notable for the presence of high forces acting between the polymer chains. Thus, Nylon 6,6, man's first completely synthetic commercial fiber, and one of the important textile materials, is based on a linear molecule whose regularly spaced polar groups give rise to high intermolecular forces. Polystyrene, in its amorphous form is a poor fiber material because its bulky phenyl groups, randomly located on the linear chain, serve to block development of a crystalline structure. Therefore, the fiber is weak and has a low softening temperature.

The research on stereospecific, or ordered polymerization, pioneered by Ziegler and Natta now makes possible crystalline polymers of styrene, propylene, ethylene, and other vinyl monomers. The *isotactic* chain, Figure 2, obtained with Ziegler and Natta cata-

continued

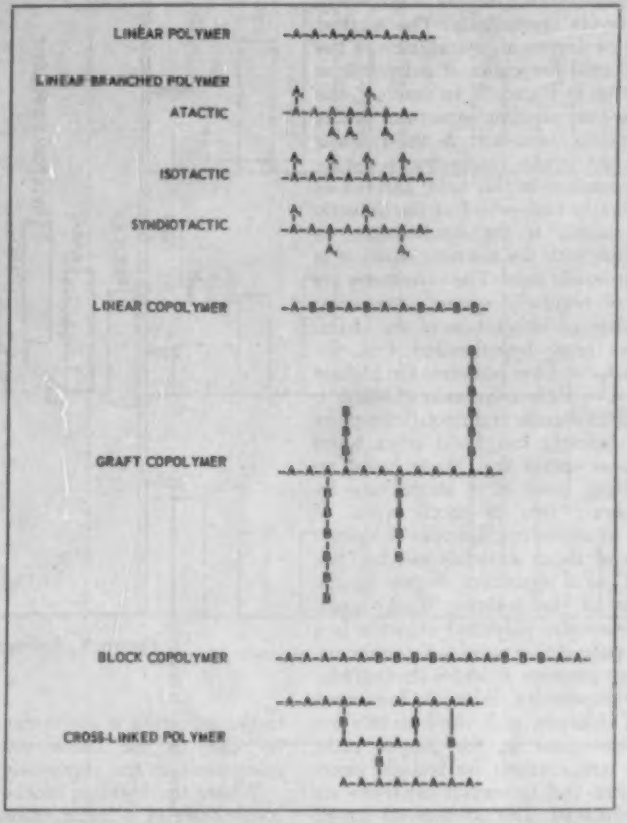

Figure 2. Schematic representation of polymer chain configurations.

Table 1. Chemical nature of repeating unit vs. properties.

Polymer	*Repeating Unit*	*Chemical Resistance*‡	*Flammability*	*Heat Stability*	*Dielectric Dissipation Factor (10^6 cps. ASTM D-150)*‡
Polyethylene	$-CH_2CH_2-$	Acid and alkali resistant; swollen by hydrocarbons at room temperature; soluble in hydrocarbons at > 70°C.	Burns	Good to Excellent	.0003
Polyvinyl Chloride	$-CH_2CHCl-$	Acid and alkali resistant, except glacial acetic, conc. sulfuric; soluble in ketones, esters, chlorinated hydrocarbons.	Self extinguishing to slow burning	Fair	.02 §
Polyvinylidene Chloride	$-CH_2CCl_2-$	Acid and alkali resistant (except NH_4OH); alcohol, ester, ketone resistant; softened by certain chlorinated, aromatic hydrocarbons.	Non-flammable	Good	.06
Polytetrafluoroethylene	$-CF_2CF_2-$	Acid; alkali; oxidant and solvent resistant.	Non-flammable	Excellent	.0002
Polycaprolactam	$-\underset{\mid \atop H}{N}(CH_2)_5\underset{\| \atop O}{C}-$	Ester, ketone, alcohol resistant; attacked by phenols, formic acid, conc. mineral acids.	Self extinguishing to slow burning	Good	.02

‡ Data at room temperature unless indicated otherwise. § 50°C.

lysts possesses the degree of symmetry that favors crystallinity. The marked effect of degree of crystallinity on the mechanical properties of polyethylene is shown in Figure 3. In contrast, the *atactic* or random structure favors amorphous behavior. A third linear branched chain geometry resulting from research in this field, and not as completely understood as the isotactic and atactic, is the *syndiotactic*. In common with the isotactic chain, it is an ordered one. The symmetry is that of regularly spaced alternating branches on either side of the chain. It has been hypothesized that the syndiotactic form possesses the highest degree of thermodynamic stability.

The molecular architect (high-polymer chemist) can build other types of linear chains than those based on repeating units of a single mer by combining two or more types of mers to obtain copolymers. The properties of these materials can be "tailored" to a significant degree by the nature of the building blocks used. For example, polyvinyl chloride is a high polymer, or resin, whose processing temperature is above its degradation temperature. When its monomer, vinyl chloride, and vinyl acetate are copolymerized in the proper ratio, these temperatures are brought closer together and in certain instances are interchanged. The commercial significance of the contribution of the vinyl acetate comonomer is obvious. Softening point lowering can be attributed to the reduction in molecular symmetry due to the minor comonomer component in the copolymer chain.

Where the building blocks of each comonomer in a linear chain are, in effect, low-molecular-weight polymers, the copolymer is described as a block copolymer. Where the block or homopolymer units have significantly different properties, *e.g.*, one hydrophilic and the other hydrophobic, the copolymer can be expected to be quite different from ordinary copolymers. For example, copolymers of polyethylene terephthalate and polyoxyethylene glycol have been made wherein

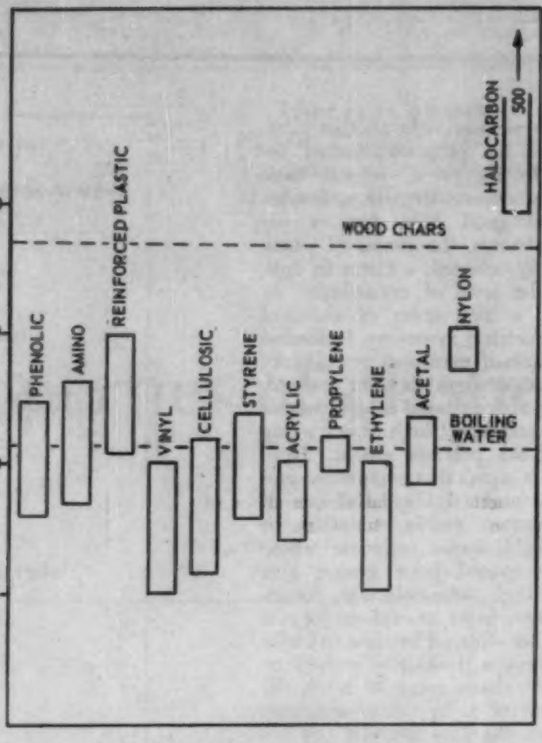

Figure 5. Average maximum use temperature, degrees F.

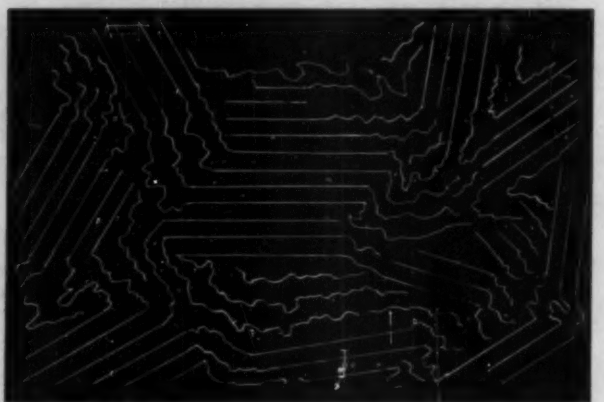

Figure 4. Schematic representation of crystalline and amorphous regions in a polymer.

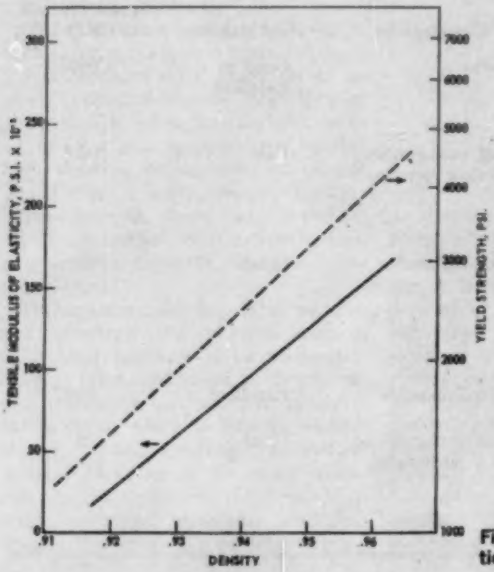

Figure 3. Effect of crystallinity on properties of polyethylene.

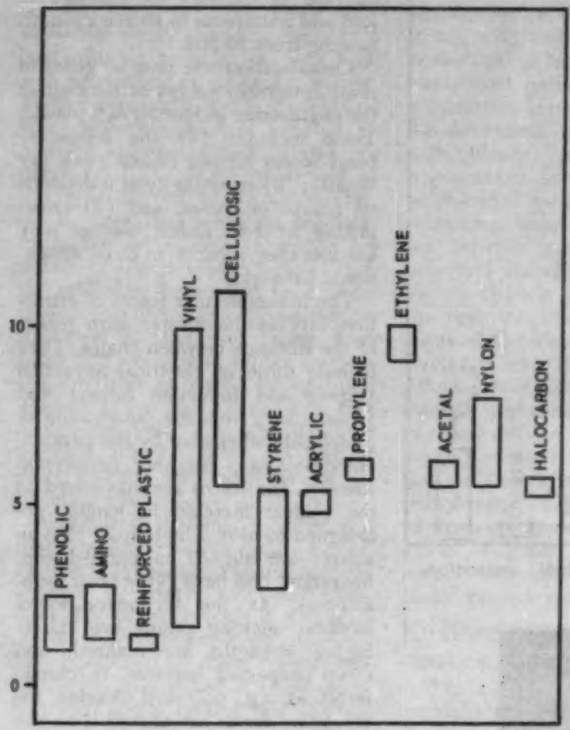

Figure 6. Linear thermal expansion coefficient /°F x 10⁻⁵.

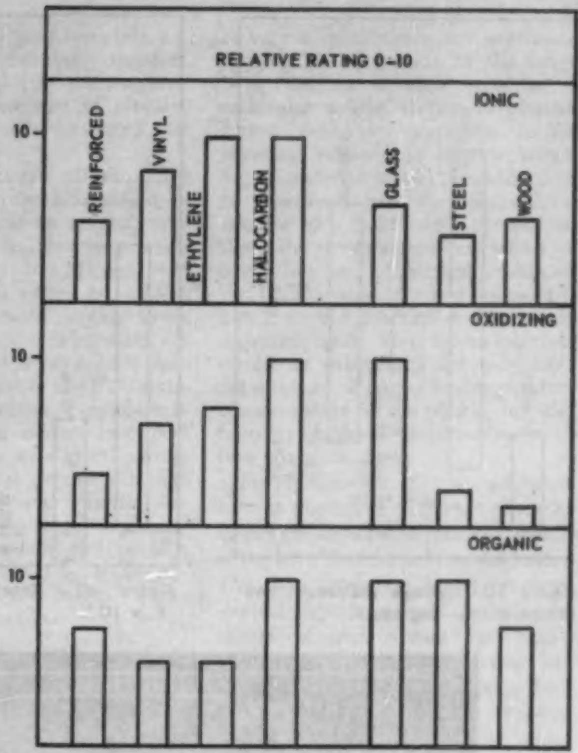

Figure 7. Average chemical resistance.

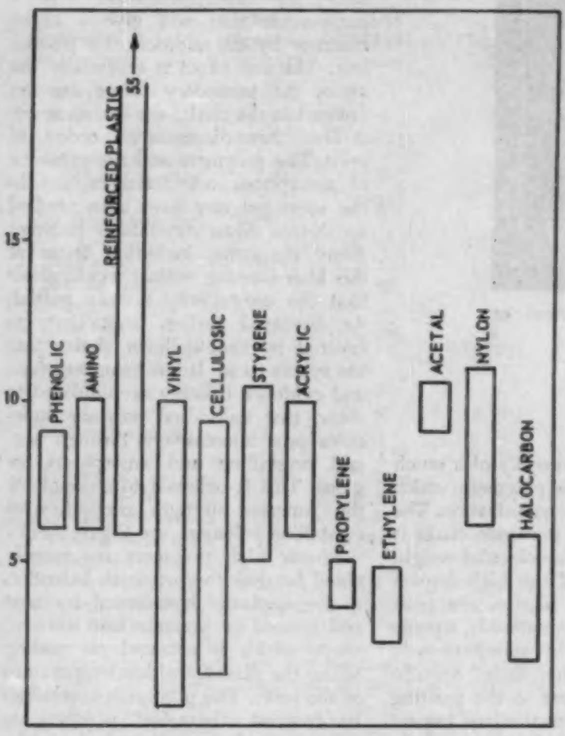

Figure 8. Tensile strength—1000 lb./sq. in.

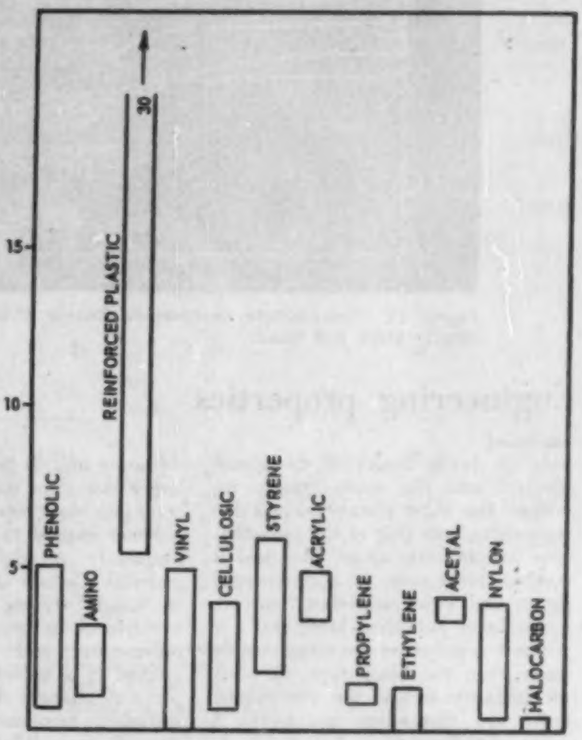

Figure 9. Modulus of elasticity—100,000 lb./sq. in.

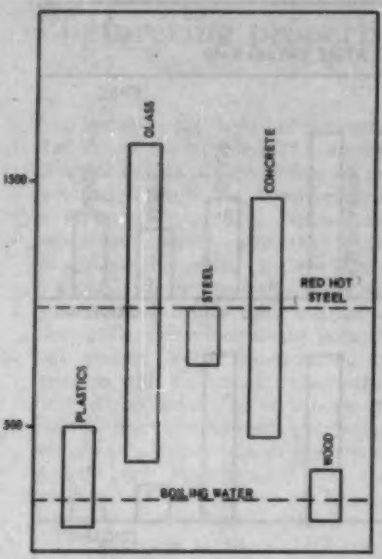

Figure 10. Average maximum use temperature—degrees F.

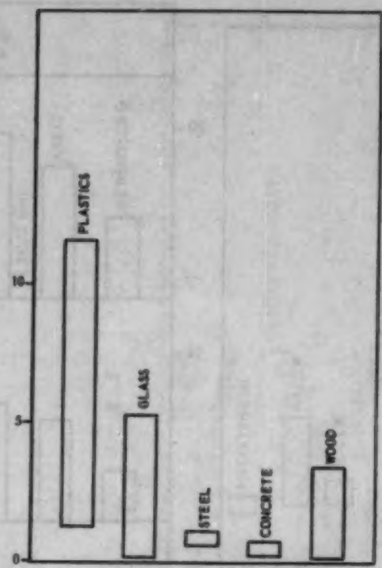

Figure 11. Thermal expansion/ °F. x 10^{-6}.

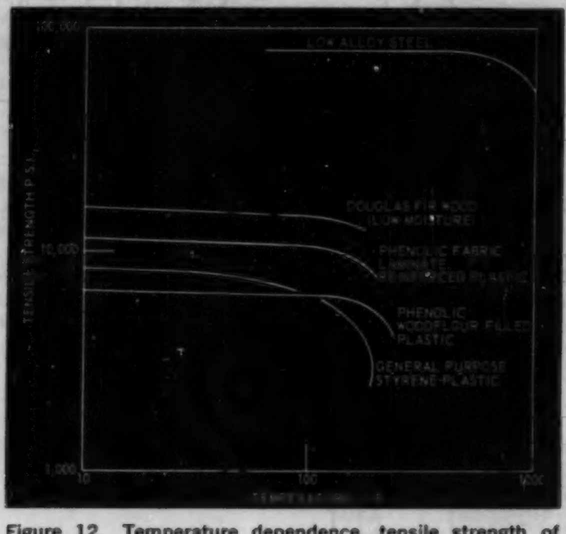

Figure 12. Temperature dependence, tensile strength of plastic, steel, and wood.

Engineering properties

continued

only 1% (mole basis) of the glycol blocked into the chain greatly increased the water absorption and dye receptivity over that of the polyethylene terephthalate alone. The field is comparatively new, in a commercial sense, and little properties data are available in published literature.

Graft copolymers are more readily made than the block type. A point of similarity is that the comonomer units are themselves polymers. A point of difference is that the backbone chain, based on one type of repeating unit, is generally of a much larger size than the polymers which enter into block copolymerization. The polymer grafted to the main chain is frequently a high-molecular-weight material. Certain of the high impact or "tough" styrene plastics are graft copolymers. In these materials, styrene polymerizes and is simultaneously grafted to a rubbery chain. Specific property changes due to the grafting include an increase in the Izod impact strength from 0.3 ft.-lb./in. notch to greater than 1.0 ft.-lb./in. notch, an increase in ductility of four-to-five-fold and a decrease in tensile strength ranging from 10-50%.

Consideration will now be given to chain interrelationships as they affect the engineering properties of a plastic. These include: (1) the secondary bond forces among chains (van der Waals); (2) crystallinity as it depends on groups of chains; and (3) cross-linking wherein chains may or may not lose their identity in three dimensional networks.

The intermolecular forces of attraction vary as the inverse sixth power of the distance between chains. They include those of electrical attraction (dipole and induction forces) and those arising from the polarization of a molecule other than by the permanent dipole of a neighbor (dispersion forces). The forces are maximized as the chains: increase in length; are designed to have a high order of symmetry; are aligned in parallel configuration; and have "very polar" substituents. As the secondary forces increase, melting points are raised, higher strengths are realized, and creep properties improve. In certain instances, *e.g.*, polyvinyl chloride, the secondary forces are of such a magnitude that the plastic is difficult to process due to its high softening temperature and poor flow characteristics. These problems can be resolved either by copolymerization with a comonomer that will give a bulky chain or by the addition of a plasticizer. The net effect is essentially the same; the secondary forces are decreased as the chains are forced apart.

The three-dimensional order of crystalline polymers and the presence of amorphous unordered regions in the same polymer have been verified by X-ray. Most crystalline polymer X-ray diagrams, including those of the fiber-forming resins, would show that the crystallinity is only partial. As discussed earlier, crystallinity is favored by simple linear chains that are symmetrical. It has been theorized and evidence is being accumulated to show, that individual polymer molecules pass successively through several crystalline and amorphous regions. This is believed to account for the superior strength properties of crystalline polymers, see Figure 4, (2)

Linear high polymers are usually noted for their thermoplastic behavior. A thermoplastic is softened by heat and formed by pressure into a useful shape which is retained on cooling below the glass transition temperature of the resin. The process is reversible. In contrast, thermoset plastics are formed simultaneously with the initiation of the cross-linking reaction that

converts the heat-fusible, linear, low-molecular-weight, molding resin to a heat-infusible material of very high and indeterminant molecular weight. Three dimensional, highly-cross-linked space polymers are held together by primary valence cross-links and are generally rigid. Many materials of this type do not soften appreciably, up to their decomposition temperatures. Primary valence cross-links are orders of magnitude stronger than the secondary forces that hold linear chains together. The properties of thermoset plastics can range from those characteristic of rubber to those characteristic of rigid, strong, hard phenolic resins. They depend on how many cross-links hold the molecule together, whether these are long or short, and the size and nature of the so-called main chains.

Vulcanized elastomeric rubber is a space polymer whose long, highly-flexible, unsymmetrical chains are held together by widely separated cross-links. The phenolic resin in a molded object is a different type of cross-linked polymer. Its short, symmetrical chains are cross-linked at many closely-spaced points, making it a polymer whose structure is quite immobile, *i.e.*, strong, stiff, and chemically resistant. In the field of high polymers, superior mechanical performance of elevated temperature is usually associated with the thermosets.

Polyblends, plastic alloys. High polymers can be physically mixed, or polyblended to achieve unique properties, *e.g.*, improved flow or processing behavior may be attained with polyvinyl chloride resins by adding high polymeric materials that lower the flow temperature. The melt viscosity of the blend is (as a rule) substantially below that of the PVC resin. Alloying may also make possible substantial upgrading of the toughness or shock resistance of a given plastic. Several commercial products in the field of tough styrene plastics are polyblends, wherein the toughness-improving polymer is some type of a rubber. Polymer blending is an important technique that makes "tailor-made" plastics possible.

Engineering properties of plastics

Within each generic group of commercial plastic materials it is possible to vary a specific property over some range. The magnitude of the range is a function of such variables as molecular weight, degree of plasticization, and copolymerization. In the chemical industry, an engineer selecting a material would, perhaps, first be concerned with the chemical resistance of a candidate material, and then the temperature at which it could be used. Chemical resistance can be estimated to a first approximation from the chemical nature of the repeating unit. The use-temperature would be estimated, not only from the mechanical properties-temperature characteristics of the plastic, but also from its chemical resistance-temperature characteristics.

In Figures 5-9 (3) the properties for the thermoset plastics (phenolic, amino and reinforced plastics) appear at the left. The rest are thermoplastics. The data given are based on commercial experience and include the effects of temperature on tensile strength, creep, chemical stability, and the like. The two bench marks, boiling water and wood-char tempera-

continued

Table 3. Comparison of weights of structures made of different materials.[a]

Functional specification	*Criterion for minimum weight*[b]	*Order of increasing weight of structure:* *SAE X4130 steel*	*Titanium alloy*	*75S-T aluminum alloy*	*Paper laminate, phenolic*	*Cast phenolic*	*Tough styrene*	*Crystal styrene*
A. Strength								
1. Axial load	γ/σ	4 (2.83)	1 (1)	2 (1.12)	3 (1.81)	6 (5.12)	7 (9.18)	5 (4.68)
2. Bending of simple rectangular beam								
a. Width specified	$\gamma/\sigma^{1/2}$	7 (2.94)	3 (1.33)	2 (1.11)	1 (1)	5 (1.63)	6 (1.97)	4 (1.39)
b. Depth specified	γ/σ	4 (2.83)	1 (1)	2 (1.12)	3 (1.81)	6 (5.12)	7 (9.18)	5 (4.68)
3. Torsion of circular shaft	$\gamma/\tau^{2/3}$	5 (2.62)	.. ..	1 (1)	4 (2.04)	3 (1.39)	.. ..	2 (1.20)
B. Stiffness								
1. Axial load	γ/E	1 (1)	3 (1.08)	2 (1.04)	4 (2.25)	5 (7.17)	7 (10.6)	6 (10.1)
2. Bending of simple rectangular beam								
a. Width specified	$\gamma/E^{1/3}$	7 (2.40)	6 (1.70)	2 (1.22)	1 (1)	5 (1.41)	4 (1.40)	3 (1.35)
b. Depth specified	γ/E	1 (1)	3 (1.08)	2 (1.04)	4 (2.25)	5 (7.17)	7 (10.6)	6 (10.1)
3. Torsion of circular shaft	$\gamma/G^{1/2}$	5 (1.65)	.. (1.30)	1 (1)	5 (1.66)	6 (1.77)	7 (2.24)	3 (1.62)
C. Resistance to impact Bending of simple rectangular beam	$\gamma E/\sigma^2$	7 (8.60)	1 (1)	2 (1.30)	3 (1.57)	5 (3.93)	6 (8.53)	4 (2.33)
D. Resistance to resonant vibration Axial load	$\gamma/CE\sigma^{n-1}$	2 (22.0)	.. ..	.. ..	1 (1)	4 (75.0)	5 (120.9)	3 (73.2)

[a] Numbers in parentheses give relative weight of structure for material concerned in terms of weight of lightest structure.

[b] Code for symbols:

γ = Specific weight in lb./cu. in.

σ = Tensile yield stress in p.s.i.

τ = Ultimate shear stress in p.s.i.

E = Young's modulus in p.s.i.

G = Shear modulus of elasticity in p.s.i.

C = Stress coefficient of damping capacity in p.s.i.$^{1-n}$

n = An empirical dimensionless number

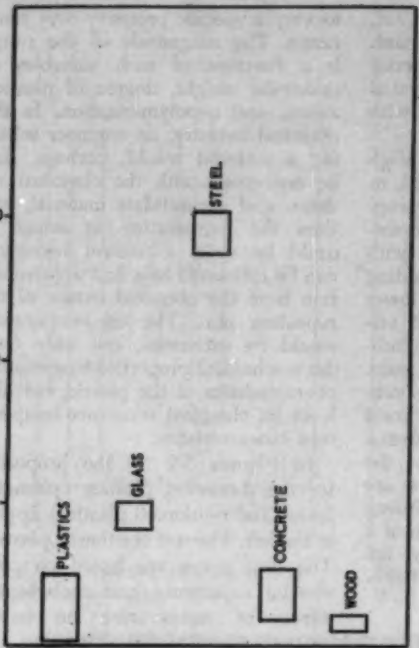

Figure 13. Modulus of elasticity—1,000,000 lb./sq. in.

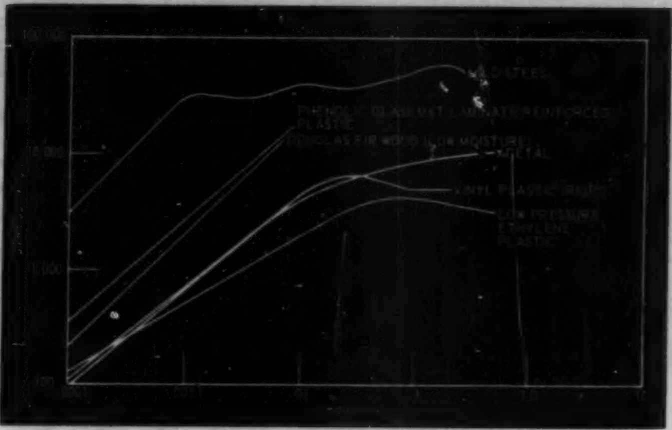

Figure 14. Stress-strain characteristics of plastics, steel, and wood at room temperature.

tures, serve to stress that plastic materials, as a group, are best used at temperatures below the wood-char point of 380-400°F. The space or cross-linked polymers used in the manufacture of thermo-setting resins are generally more heat resistant than the thermoplastics based on the linear molecules. A noteworthy exception to this generalization is the halocarbon family. This is related to the fact that they are highly crystalline and that the C-F bonds are very strong. Silicone polymers are also noted for their retention of mechanical and other properties at elevated temperatures. Silicones have been included in the reinforced plastics family, although they have important implications in the elastomeric field.

The chemical engineer concerned with pipe installations in the plant would have need for data on the thermal expansion characteristics of plastics. It will be noted in Figure 6 that the thermoplastic materials, as a group, have higher expansion coefficients than the thermoset materials. The average relative chemical resistance ratings of several generic groups of plastics are compared with glass, steel, and wood in Figure 7. Note that the plastics shown are generally superior to steel and wood when in contact with corrosive liquids or atmospheres. The steel cited is ordinary structural steel. It is, of course, possible with special alloys of iron, to obtain a more chemically resistant metal. The generalities of Figure 7 are designed to be of help in the preliminary screening of candidate materials for use in a corrosive environment. More specific information is needed in making a final decision than can be presented in any one chart.

The range of strength (tensile strength) of commercial plastics varies from less than 1000 lb./sq. in. for one type of plasticized PVC to upwards of 60,000 for a glass-fiber reinforced material in which a thermoset resin is commonly used to hold the glass fibers in place. The tensile strength data in Figure 8 are based on standard ASTM tests and represent short-time values. In many design situations the factor controlling material choice is stiffness, or modulus of elasticity.

The data in Figure 9 indicate that plastic materials come in a wide assortment of flexibilities. The variation in flexibility within a generic family group is a function of the composition, process conditions, and plasticization. It is possible to plasticize PVC from a peak modulus value of 500,000 lb./sq. in. for the resin alone, down to a liquid. The stiffness of reinforced plastics depends on the type of reinforcement used and its configuration in a particular structure. Maximum values are obtained with high modulus glass fiber and minimum values with the organic high polymer fibers.

The light weight of plastics is used to advantage in construction and piping. Depending on the physical form, type of plastic material, and reinforcement used, plastics range in weight from 2 to over 130 lb./cu. ft. The very light material would be a foamed or a low density cellular plastic product; the heavy material, a highly filled plastic. The resins themselves range in density from something less than 0.9 for polypropylene up to about 1.5 for PVC. The thermal conductivity of plastic materials is low and by fabricating low density cellular foam materials from high polymers, it is possible to make some of the most efficient thermal insulators known today. The practical observation that a plastic pipe made of vinyl resin does not sweat in a humid atmosphere when carrying cold water is reflected in substantial savings in piping installations. The efficient insulation qualities of a polystyrene or a urethane foam have given the engi-

Table 2. Thermal conductivity of plastics and other insulating materials.

Material	*Apparent Density lb./cu. ft.*	*Thermal Conductivity @ 20-30°C. btu./(hr.) (sq. ft.) (°F/in.)*
Styrene Plastic	66.5	0.80
Styrene Foam	2	0.22
	6	0.24
	10	0.25
Cork Board	10	0.3
Rock Wool	12	0.26
Window Glass	150	4.8
Glass Wool, curled	8	0.29

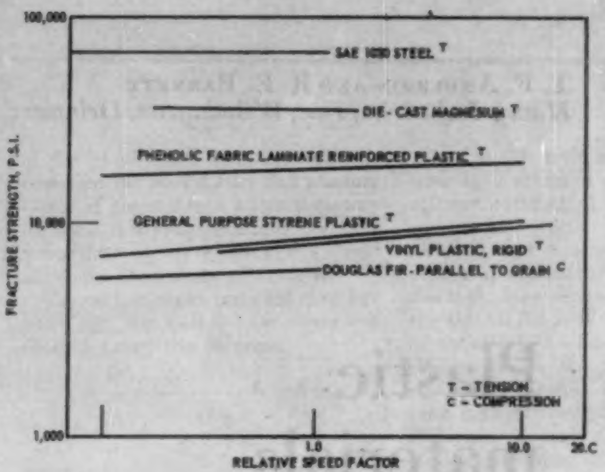

Figure 15. Time dependence, strength properties of plastics, magnesium, steel, and wood.

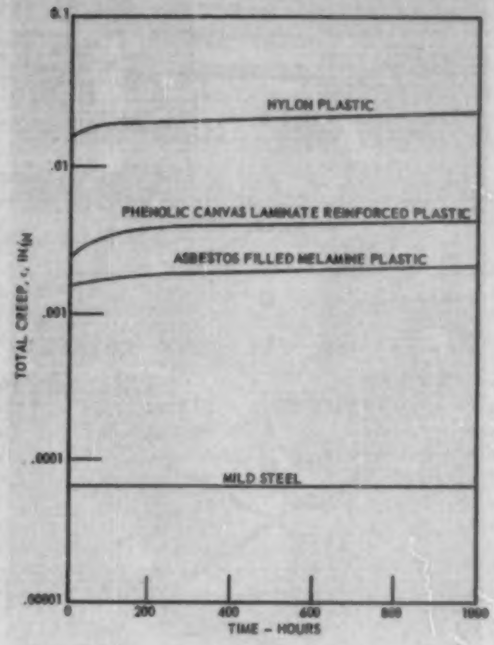

Figure 16. Creep characteristics of plastics and steel, room temperature, 2000 lb./sq. in. tension.

neer considerable freedom in solving difficult heat flow problems. In Table 2 are typical thermal conductivity data for solid plastics, low density cellular plastics, and other types of thermal insulating materials.

Data on plastics and other materials compared. The average maximum use-temperature of plastics, as a class, is substantially lower than the inorganic products — glass, concrete, and steel. However, the more heat-resistant plastics are superior to wood, Figure 10. In Figure 12, additional data on the temperature dependence of plastics and other materials are given. Short-time tensile strength is plotted against the temperature in °F. Note that the tensile strength of the linear thermoplastic material based on styrene decreases significantly at the lowest temperature level of any of the materials shown. Further, its tensile strength vs. temperature curve is one whose slope is constantly decreasing up to the glass transition temperature, *i.e.*, sharp strength drop off point. In contrast, the plastic materials based on three dimension or space type polymers show little drop off in strength until the region of rapid change is reached.

The thermal expansion characteristics of plastics are such that when used in combination with steel, for instance, special design allowances must be made for their high coefficients, Figure 11. This is a design problem that has many thousands of successful solutions but there are certain plastics too brittle to accept inserts of a material of widely different thermal expansion characteristics. It will be noted from Figure 13 that the stiffest plastic has a modulus of elasticity approximately one-tenth that of a structural steel. This maximum level of modulus is achieved by reinforcement with high modulus glass fibers. Several research projects are under way to develop reinforcement materials and geometric configurations that will increase the stiffness substantially above its current maximum of about $5x10^6$ lb./sq. in.

The structural engineer frequently can identify a material from its stress-strain curve. In Figure 14 are typical stress-strain curves for several plastics, mild steel, and wood. The logarithmic nature of this plot tends to minimize some of the differences discussed, but it does show that the plastic materials of today are less stiff and not as strong as steel.

An awareness of the time- or rate-sensitivity of the mechanical properties of plastics is important to the designer. Figure 15 shows the marked effect that testing speed has on the breaking strength of plastics in contrast to the relative insensitivity of metals over the range of speeds shown. Space-type thermoset plastics are less speed sensitive than thermoplastic linear materials. This can be due to the secondary forces among the chains in the linear polymer. These forces increase with speed and decrease with temperature rise. When loading rates are very low (as in creep tests) the linear polymers show a greater tendency to deform than the cross-linked polymers under the same load conditions. Figure 16 shows that the mechanical behavior of plastics is distinctly different from steel.

The justification for using plastic materials in many applications is that they are light in weight and have favorable strength-weight ratios when compared with other materials. A careful analysis of several design criteria, Table 3, showed that where benefits can be derived from the geometry of the system, plastic materials make the lightest weight structures possible. This is particularly true in sandwich panels where low density plastic materials are used as cores.

Although a great deal of data is available on the plastics in today's market place, it is obvious that much more is needed to satisfy the requirements of engineers faced with challenging design problems. Further, adequate dissemination of data already available has yet to be achieved. The plastics industry recognizes these needs and is attempting to fulfill them through various company and technical and trade society "properties research" and educational programs.

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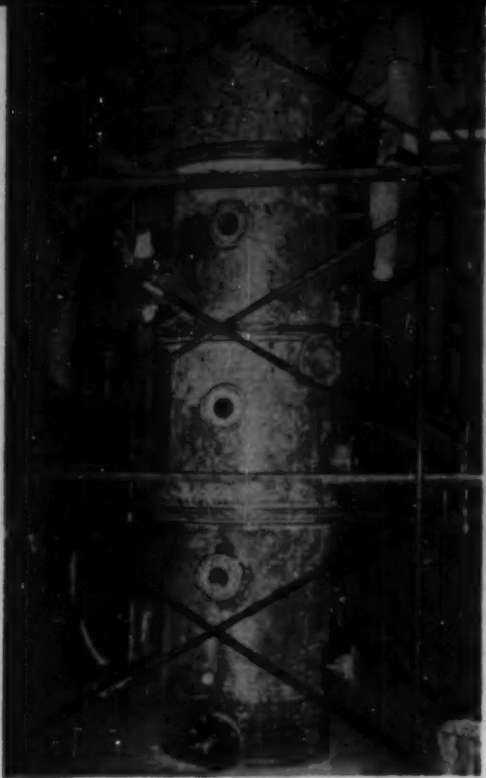

Figure 4. Sieve plate reaction column, 36-in. diam. by 31-ft. high.

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Plastic materials in structural applications

WHEN fiber glass-reinforced polyesters first became generally known, many people felt that they were the answer to almost all structural problems. As a result early difficulties were encountered because people forged ahead without realistic determinations of the properties of the new materials. Examination of Table 1 shows that it is possible to approach the tensile, compressive, and flexural strength characteristics of cold rolled steel using oriented, fiber glass-reinforced polyesters. In fact, laminates made under laboratory conditions, by pressure molding, yield products which are much stronger in these properties than plain, cold rolled steel. However, comparing the flexural modulus, it is seen that the stiffness of steel is 15 to 20 times greater than the stiffness of fiber glass-reinforced polyester plastics; and that interlaminar shear, measured in tension, runs 10 to 20 times greater for plain, cold rolled steel.

One other set of important properties that should be noted are the percent of ultimate tensile, compressive, and flexural strengths which can be carried as long term loads. For the fiber glass-reinforced polyester materials these run to 20% vs. 80% or more for steel. It should also be noted that the percent of ultimate shear strength which can be carried as long term load is 50% in the case of the polyester fiber glass laminates, compared to more than 80% in the case of plain, cold rolled steel.

The properties given in Table 1 were developed over many years of laboratory and field testing and the values shown have been used in the strength calculations in all of the illustrations which follow. It should be pointed out that the physical properties of polyester-fiber glass laminates vary considerably with the fiber glass and its surface treatments, and with the particular polyesters used in making the laminated structures.

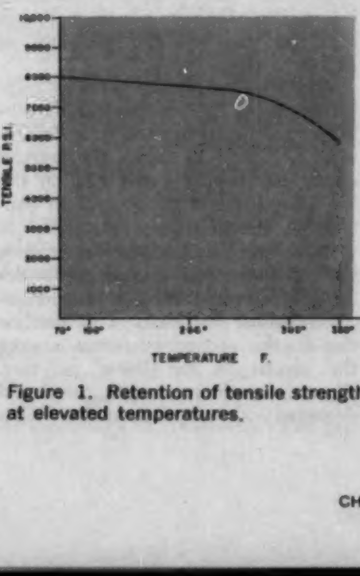

Figure 1. Retention of tensile strength at elevated temperatures.

Since many of the structures are used at elevated temperatures, Figure 1 is of importance. It shows the retention of tensile strength at elevated temperatures.

Although it is important to note that the properties shown in Table 1 and Figure 1 were obtained with a specific chemical-resistant polyester, they represent the physical properties of a wide group of the chemical-resistant polyester, fiber-glass laminates.

Tanks

In the days when the safety factors were unknown for plastic equipment undergoing long term stresses, and people were using the safety factors for steel and adding on a calculated guess, tanks were being designed and built with a safety factor of 5, instead

of the present 15. This criterion was based on the assumption that a safety factor of about 3 to 1 was satisfactory for noncorrosive applications, and that the additional safety factor of 2 would allow for the effects of corrosion.

For certain tanks installed over five years ago, the wall thickness was calculated using the formula:

$$t = \frac{pr}{s} = \frac{7 \times 60 \text{ in.}}{\left(\frac{8000}{5}\right)} = 0.262 \text{ in.}$$

where:

t = thickness, in.
p = pressure, lb.
r = radius, in.
s = allowable stress, lb./sq. in. = $\dfrac{\text{ultimate tensile}}{\text{safety factor}}$

As a result, a nominal ¼ in. wall was used and, because of process variables, the tank walls actually turned out to be closer to ⅜ in. thick. However, this was largely due to a higher resin-to-glass content, so that the tensile properties of the final material were probably somewhat lower than the 8000 lb./sq. in. used in the design calculations.

In use this tank is in violent agitation. It contains a large, full-sweep agitator rotating at approximately 2 rpm., which carries approximately a one-foot wall of a mixture of sulfuric acid and sulfonated fish oil around the tank. Measurements made against the side of the tank show a deflection of about 0.050 in. as the wall of the solution passes the point of measurement. This would indicate that the tank is slightly egg-shaped four times a minute. No calculations have been made concerning the effect of this cyclic stressing of the material, but it is evident that the stress in the tank is not a simple static loading.

Recent examination shows the tank sidewalls to be translucent still, with no signs of cracking or crazing. In reinforced plastics, when the material is stressed beyond its elastic limit, but not stressed to failure, translucency is greatly decreased, or completely destroyed.

Since most current tank designs are based on a safety factor of 15 to 1, using a composite structure, these older tanks are being studied with much interest. They can provide information which will allow reduction of tank walls, thus reducing weight and cost of cylindrical tanks.

In Figure 2 are shown four cylindrical tanks used to store concentrated sodium hypochlorite solutions at a truck loading platform. These tanks were built with a safety factor of about 10 to 1. They have now been in service just over 3⅝ yr. When the tanks were installed, heavy valves were attached to the bottom outlets without external support. After approximately a year, small leakage was discovered in two of the tanks at the point where the outlet was joined to the tank. These were repaired and all four valves were exteriorly supported. No further difficulty has been encountered. Although it is somewhat difficult to calculate, it appears that the safety factor at the point of failures had dropped to 1½-2 to 1 from the load of the external valves.

Because of its low modulus, it is not economically feasible to consider using plastic ribs in large rectangular tank design. Steel ribs are used in all large rectangular tanks. The steel ribs are then covered over with polyester

continued

STRENGTH PROPERTY	POLYESTER LAMINATES				PLAIN COLD ROLLED STEEL
	chopped strand mat 20% glass 80% poly.	composite constr.	plain weave woven roving non oriented 55% glass	2-1 oriented weave woven roving 55% glass (tested in strongest direction)	
tensile psi	8,000	8,000 to 30,000	21,000	30,000	30,000- 50,000
compressive psi	30,000	30,000	30,000	30,000	30,000-50,000
flexural psi	14,000	14,000 to 30,000	24,000	30,000	30,000-50,000
flexural modulus psi	7×10^5	7×10^5 to 2.5×10^6	1.5×10^6	2.5×10^6	30×10^6
interlaminar shear strength psi	2,000	2,000	1,800	1,800	20,000-40,000
percentage of ultimate tensile compressive and flexural strengths (carried as long term load)	20%	20%	20%	20%	> 80%
percentage of ultimate shear for long term load	50%	50%	50%	50%	> 80%

Table 1. Physical properties of polyester fiber glass laminates and cold-rolled steel.

Plastics on the job

fiber glass for protection of the steel from corrosive materials.

Covers

The design of covers for tanks and towers is relatively simple, in diameters up to 8 or 9 ft., regardless of whether the cover is flat, dished, or cone-type. However, as the diameters increase above this point, the low modulus of the plastic materials makes the design of flat covers, and even dished and cone covers, more complex.

Figure 3 shows a 23-ft. diam. dished cover used on a hydrochloric acid storage tank by the duPont Company. No snow load or other external loads were involved and head room permitted the use of a dished cover. This cover, with a 5/16 in. wall, was made in two sections for ease of shipment and joined in the field by application of a wet seam both inside and outside, after being put in place. Complete with its internal ribs made of the same chemical-resistant polyester fiber glass, this entire cover weighed less than 2500 lb. This cover has been in service for over three years and is in excellent condition, with no signs of decrease in translucency due to excessive stresses.

Packed towers

A number of packed-column type, vertical scrubbing towers for service in various atmospheric pollution control and other process operations have been constructed. This equipment removes gases, vapors, and particulate matter from vent or other gaseous process streams by diffusion, impingement, and solution of these into a suitable liquid medium during flow of the gas stream (usually countercurrent) over a large surface area of inert packing which is continuously re-wetted with the sorbing liquid. The operating principles and functional design for these units are well known and will not be discussed here. Typical installations listed below.

Date	Customer	Size	Service
12/54	Stauffer Chemical Co.	18″ diam. × 10′-0″ high	HF-HNO_3
3/56	Nyotex Chemical Co.	12″ diam. × 10′-0″ high	HF-SiF_4-SO_2
11/55	Dow Chemical Co.	2′-6″ diam. × 11′-0″ high	Cl_2
6/56	Harshaw Chemical Co.	42″ diam. × 18′-0″ high	HCl-NH_3

Economic considerations governing selection of reinforced plastics as materials of construction involve cost and service life comparisons with other alternative materials. Formerly many applications handling corrosive materials could be processed only in expensive ceramic or alloy fabrications or, less satisfactorily, in lined or coated steel structures. Reinforced plastics materials of construction have given excellent service under very corrosive conditions. Not only are properly selected materials inert to the corrosive environment, but since the materials are inherently lightweight, strong, and tough, it has been found possible to utilize fiber glass laminate construction for entire structures, with resultant savings in fabricating, shipping, and erecting costs.

Structural design requirements for this type equipment in reinforced plastics involve the same general considerations as for metal construction, with the following additional provisions:

Reinforced plastic laminates are known to experience an initial fall-off in physical strength in liquid exposure service, the extent of which can be minimized by proper selection of resins and reinforcements. When these components have been selected with due regard for the service conditions, and good laminating procedures are followed, this decline in strength gradually tends to level off after the equipment is placed in service, and usefully high values are retained indefinitely. However, in large or highly stressed structures, good practice requires safety factors of 10 or 15 to 1, based on dry, room-temperature strength values. The service load calculations are usually based upon anticipated maximum service pressure, if the tower is to be flooded or plugged. Test pressures commonly are set at 1.5 times maximum pressure.

A further reduction in laminate physical properties occurs in high temperature service due to increased thermoplasticity and *creep* of the resin. This is reversible with temperature drop, as long as upper temperature limits are not exceeded. This factor does not influence design in most scrubber applications since low temperature operation is usually specified, but may require special consideration in certain reactor designs. Use of somewhat higher safety factors will adequately provide for this.

Mechanical loads required to be

Plastics in action

Figure 2. Cylindrical tanks, Kuehne Chemical Co.

Figure 3. 23-ft. diam. dished cover. Dupont.

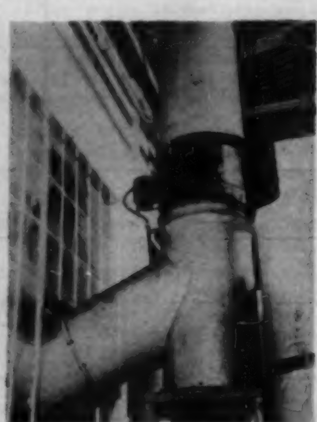

Figure 5. 30-in. diam. stack (base). Wallingford Steel Co.

sustained by these structures, in addition to hydrostatic pressures, include weight of the flooded packing, and other tower internals, all of which are transferred to and carried by the sidewalls through integrally mounted support rings. Some designs of large units require somewhat increased wall thickness in the section of the tower below the packing support member to carry this column loading. Calculation of required wall thickness involves merely the determination of the applied compressive load and provision of sufficient thickness to withstand these in edge loading. Since height/radius (l/r) ratios for the highly loaded lower section only are usually quite small, buckling due to column loading is usually not a factor. Similarly, if the design for edge loading of the column wall includes adequate safety factor, applied shear loads will also be held within safe limits.

The packing support member, or grid bar assembly requires further discussion. The grid bars, which are carried on an inner ring, bonded or flanged to the column wall, or on a ring supported between flanged column sections, are required to span the diameter of the column, be strong and rigid enough to carry the substantial weight of wetted packing, and yet allow free gas flow from the lower plenum section up into the packed section as well as free liquid flow in the reverse direction. A design has been evolved wherein bars molded of a lengthwise, unidirectional, fiber glass-reinforcement are set on edge, with ends bearing on the support ring, and held separated and kept from falling over by edgewise-mounted separator strips of corrugated fiber glass sheet stock. The grid bar assembly, with the components adhered at points of contact by resin adhesive, provides a strong, rigid, packing support grating which permits essentially unobstructed gas and liquid passage. The use of unidirectional reinforcement is favored in this application since a smaller beam having the required stiffness and strength can be provided, compared to that necessary if anisotropic reinforcement is used; also because, in fabrication, these can be sawn from sheet stock parallel to the "grain" of the reinforcement. The edges thus exposed are not subject to loss of strength by edge-penetration and wicking of the solution along the filaments, as might be the case with other types of reinforcements.

Structural requirements and dimensional tolerances required to be met:

Components

Maximum deflection of each sieve plate under liquid load of 300 lb.: ¼ in.

Overall length of each main body section: ±1/16 in.

Flatness of fiber glass plastic flanges: ±.015

Flatness of sieve plate: ±.010 in gasket area.

Assembly

Each sieve plate when mounted on body section to be level to the earth within ⅛ in., non-cumulative from one to the next as erected; column to be straight and plumb; maximum deviation from plumb permitted—⅜ in. over entire height of column.

Fit-up of external downcomers to body section nozzle ±1/16 in. on centers, with gaskets in place and bolts torqued uniformly. Downcomer flanges to match face-to-face within 0.015 in. Entire column to be subjected to hydrostatic leakage test at 40 psig, measured at the bottom with column full of water (it is of interest to note that this unit contains about 16,000 lb. of water when fully flooded.)

Of special interest is a sieve plate reaction column recently completed for one of our more exacting customers, Figure 4. This unit was comprised of a base section, seven intermediate sections, and a head section, each 36-in. diam., with a total assembled height of 31 ft. Interconnection between the sections was accomplished by eight external downcomers, all flange-connected to the column. Each pair of main body section column flanges clamped a flat sieve plate bearing 1200 precision drilled 0.125-in. diam. holes. In addition to the downcomer connections, each body section mounted additional flanged nipples for connection of other piping, inspection, and hand holes.

The structural design for specifications (box, left) was approached as follows:

Shell: Wall thickness required to withstand 37.5 psi test pressure = ⅜ in.; S.F. = 10
Check-out of wall thickness to withstand compressive load.
Total dead weight (shell, steel components, etc.) 3600 lb.
Live load due to guys, piping, wind load resultant 2400 lb.
Total, 7000 lb.
Total load/circumference = 62 lb./in. or *ca.* 250 psi; thus S.F. is high.

Wall thickness of head and bottom sections was arbitrarily increased 33⅓%. A support for the bottom section designed to carry the total weight of 23,000 lb. utilizes concentric fiber glass laminate rings with the annular space between these filled with a bonded balsa core to prevent buckling. A standard 1:1 pressure head design was used for the heads.

Sieve plates:

Design of these was checked by several means as follows:

a. Tube sheet formula which assumes no support provided by tubes

$$t = \frac{FD}{2}\sqrt{P/S}\ ;$$

$$t = \frac{1\ (36)}{2}\sqrt{0.29/500} = 0.45 \text{ in.}$$

where:

t = thickness of sheet
F = factor of restraint at ends (varies between 1 and 1.25)
D = diameter
S = allowable working tensile stress
P = design pressure or load

b. Circular plate deflection formula:

$$\Delta = \frac{3(w)(r)^2}{16\pi t^3 E}(1-\mu)(5+\mu)$$

$$\tfrac{1}{4} \text{ in.} = \frac{3\ (300)\ (18)^2}{16\pi t^3 (0.5 \times 10^6)} = 0.785$$

where:

Δ = deflection
w = total load
r = radius
t = thickness of plate
E = modulus of elasticity (a degraded value was used here)
μ = Poisson's ratio = small

c. Simple beam formula (calculated for strip of material of width equal to spacing between two adjacent rows of holes):

$$\frac{300 \text{ lb. load}}{1018 \text{ sq. in. area of plate}} = 0.267 \text{ psi}$$

$$\text{assume plate weighs 50 lb. add } \frac{0.05 \text{ psi}}{0.32 \text{ psi}}$$

$$M = \frac{0.32\ (36)^2}{12} = 32 \text{ in.-lb.}$$

$$S = \frac{M}{f} = \frac{32}{1000} = 0.032$$

(where f = degraded flexural strength with S.F. = 10)

Plastics on the job

$$S = \frac{bd^2}{6} \text{ or } d = \frac{65}{b} = \frac{0.6 \times 0.032}{0.875}$$

$= 0.45$ in.; (call it ½ in.)
($b = 1$ in. strip, less ⅛ in. holes)
d. Deflection:
(see Δ formula below.)

A final thickness of 0.625 in. was decided upon.

Flange design:

While standard Haveg Type B (150 psi crane C.I. pattern) flat face flanges were used for all small flanges, the customer expressed a preference for using the THEMA standards for design of the large body flanges, thus providing a narrower flange face, smaller bolt circle diameter, and larger number of bolts than the usual ASME-API standards. Higher gasket clamping and seating pressures would thus be applied to the 0.125 in. thick, 40-60 durometer, neoprene gaskets to be used. Pertinent dimensions of these and our method of check-out of the design follows:

Flange dimensions: 36 in. I.D., 43¾ in. O.D., thirty six-⅞ in. bolts on 39¼ in. BCD. at test pressure of 37½ psi, load per bolt =

$$\frac{\frac{\pi}{4}(36)^2(37.5)}{36 \text{ (bolts)}} = 1057 \text{ lb./bolt}$$

Moment arm for flange deflection = 1.625 in. (distance between bolt circle diameter and I.D.)

Note: While steel back-up rings were used under the bolt heads on the backs of flanges to add stiffness and reduce deflection under load of the fiber glass laminate flanges, these calculations ignore this contribution.

Moment developed by pressure = $1057 \times 1.625 = 1720$ in.-lb. In service, this is applied over the length of arc between adjacent bolts which is 3.25 in.

$$S = \frac{3.25\,(7/8)^2}{6} = 0.4;$$

$$\text{Fiber Stress} = \frac{1720}{0.4} = 4300 \text{ psi}$$

Since this a safety factor of about 5, and additional stiffness is provided by the steel as described above, the flange was considered to be adequately designed.

The service in which this unit is placed is understood to be extremely corrosive. The translucency of the laminate is an important advantage (in this and in most instances) since incipient plugging of the reactor with solids can be detected in advance of real difficulties. As a further protection and aid in retention of translucency in outdoor exposure, a special ultraviolet-resistant resin was used in the external ply of glass reinforcement, and the entire unit subsequently coated with a U.V.-absorbent lacquer. All of the customer's dimensional and test requirements were fully met.

It appears safe to say that the requirements for translucency, corrosion resistance, and structural strength can not be complied with in total aspect by any other single material of construction at this time, regardless of cost. In any other material, or combination, having the required corrosion resistances to the specific chemical environment used in this process, the final cost to the owner would have been higher by a large factor.

Stacks

Reinforced plastic stacks have many advantages. They are more chemical resistant than plain steel stacks and lighter in weight, which make for lower-cost foundations and overall lower-cost installation. In addition, when corrosion-resistant guying cables are used, these stacks are essentially maintenance free, requiring no exterior painting to protect them from the weather and area environment. Where severe chemical corrosion exists, requiring stacks of special alloys, the reinforced plastic stacks are much cheaper in initial cost and, in certain applications where only tantalum is suitable, the price differential is several orders of magnitude. Wooden stacks, which find use in a wide variety of applications, frequently give excellent performance. During shutdowns, however, drying out of wooden stacks frequently brings about collapse with a total loss.

Because of today's high stack-maintenance costs, reinforced plastics stacks warrant consideration in installations where the actual chemical corrosion does not make the plastic stack mandatory.

In the general design of stacks, the considerations are essentially the same for reinforced plastic stacks as for those made of other materials of construction. In most cases, it will not be necessary to allow extra material for a corrosion margin as in calculating the material thickness of steel stacks.

Given the stack diameter, height, location of guy cable anchors (if guys are used) etc., the stack must be designed to support its weight and to prevent turning over and/or buckling under high wind pressures. Normally stacks are designed to withstand 100 mph wind velocities or a wind pressure of 25 lb./sq.ft. of projected area.

In general, the reinforced plastic stack materials will have compressive and flexural strength near 20,000 psi at 265°F. To obtain a liberal safety factor, design values of 2000 psi are used for these stresses. Using this 2000 psi figure, an 8-ft. diam. x 150 ft. high stack, with guy cables at the 80- and 120-ft. levels, will have a calculated wall thickness ranging from 3/32 in. at the top to 5/16 in. at the bottom. In this case, a 3/8 in. wall thickness might be considered throughout to give sufficient stiffness to the sections for handling.

Figure 5 shows the base of a stack at Wallingford Steel Company, Wallingford, Conn., where the reinforced plastic stack was selected because of its chemical resistance, low initial cost, and low installation and maintenance costs.

Sometimes special installation considerations dictate unusual constructions. Figure 6 shows sections of polyester fiber glass-lined steel stacks. These stacks which were 5, 6, and 7½ ft. diam. x 80 ft. tall, were required to withstand a 100 mph. wind load, unguyed. Design calculations showed that these stacks could be satisfactorily made of reinforced plastics by the use of both circumferential and vertical stiffening ribs. However, initial costs for the all-polyester stacks were approximately 20% higher than for the polyester fiber glass-lined steel stacks. Because this was a government contract in which the low bid, if acceptable, had to be taken, the polyester fiber glass-lined steel stacks were selected, although it is quite probable that the price differential will disappear, due to the cost of maintenance coatings on the exterior of the stack, after only a few years of service. It is possible, however, that the plastic-lined stack definitely has application where the short time expected use of

$$\Delta = \frac{w L^4}{384\, E \left(\frac{bd^3}{12}\right)} = \frac{0.32\,(36)^4}{384\,(5 \times 10^6)\ \frac{(0.875\,(0.5)^3}{12}} = 0.28 \text{ in.}$$

Figure 6. Stack sections (lined steel), 5-ft., 6-ft., and 7½-ft. diam. by 80-ft. high.

Figure 7. Tank trailer, 4300 gal. capacity. Kuehne Chemical Co.

equipment makes the lowest initial cost the governing factor.

Tank trailer

A large manufacturer of commercial and industrial bleaches required a trailer-mounted tank for local and out-of-state deliveries of high-test sodium hypochlorite bleach solution. Successful plant experience, for a period of several years, with Haveg 7710 fiber glass laminate stationary process tanks in this service encouraged this company to feel that, if the structural design problems could be solved, a unit of this type would have marked advantages over the rubber-lined steel transport tanks then in use. These advantages would include lighter weight resulting in a higher payload as well as maintenance-free operation, since this monolithic molded tank would not be subject to the difficulties caused by pinholes, delamination, and bond failures of coatings on steel. The specifications required to be met were as follows:

Capacity: 4300 gallons (6 ft. diam. x 22 ft. overall).
Unloading: 20 psi working pressure 30 psi test pressure. (measured at top of tank).
Weight of Chassis: 6600 lb.
Payload @ 10 lb./gal. 43,000 lb.
Weight of tank 3000 lb.
Weight distribution King pin 19,350 lb.
Rear tandem axles 35,000 lb.
Gross loaded weight 54,350 lb.
1—Manhole & several flanged nozzle openings.

A further requirement that the exterior appearance conform to the highest standards of durability, brightness and gloss was also imposed. The design of this unit was approached by first selecting a suitable chassis. A standard, tandem axle, milk tank trailer was modified.

The tank design proceeded in the following steps:

Pressure requirements:

A standard 1:1 pressure head design was selected for the fore and aft ends. Hoop tensile calculations developed that a ⅝ in. wall thickness would provide for the 30 psi test pressure with a safety factor of 10. Thickness of the head was increased by 25% over shell thickness.

Bearing load:

The total bearing surface area was measured to be 22 sq. ft. It was determined that the unit bearing load (total weight/total support area) was 15 psi, a very safe value.

Shear loads at saddles:

The total shear length along the support edges was determined to be 820 in., or for ⅝ in. wall thickness, the laminate area resisting shear is 410 sq. in. With a total weight of 45,000 lb., this amounts to 110 psi or a safety factor of over 100. If a shock factor of 2 and 50% effective area are considered, the safety factor is reduced to over 25, and still adequate. (Special precautions in "bedding in" the tank were taken to insure a large percentage effective bearing surface area.)

4G-deceleration stop:

Load on head;

Total pressure equals (22 ft. head or 11 psi) $\times$ (4) = 44 psi at 5/8 in. wall thickness; resistance to rupture is adequate.

Load tending to part head from wall;

Applied load/total circumference =

$$\frac{44\,\pi\,(36)^2}{\pi\,(72)} = 794 \text{ lb./in. of circumference.}$$

For ⅝" wall thickness, unit stress = 1588 psi : S.F. = 12.

Shear at surge plate edge:

Total length of edge (76 in.) $\times$ 0.625 = 48 sq. in.

Total load = $44 \times 2/3 \times \pi(36)^2$ = 120,000 lb.

$$\frac{120,000}{48} = 2700 \text{ psi; S.F.} = 5+$$

Note: 2/3 of total load on head is taken since 1/3 of area is supported by surge plate.

The completed unit is shown in Figure 7.

Prior to releasing this unit to the customer, our Engineering Department subjected the assembled trailer to severe road testing with the tank both full and half-full. The unit was driven at high speeds over rough mountain roads and subjected to full emergency stops with wheels locked and skidding. Pressure testing followed the rigorous road test schedule. No evidence was found of any damage or distress in any of the components or assembly.

This trailer has now been in daily use for more than nine months without developing any difficulties. It has fully lived up to all expectations and we are confident that years of economical maintenance-free operation lie ahead. The original cost was quite competitive with that of a lower-payload lined-steel tank unit and the larger payload capacity of the Haveg tank, due to lightweight plastic construction, pays a clear and free bonus to the owner with every load.

Materials are now at hand which, when properly engineered and handled by experienced molders and fabricators, can assure the long service life required in chemical service applications. It is to be anticipated that the near future will see an ever increasing number of applications of the type described in this article; the only limitations as to shapes, sizes and uses being the imagination of the designer—in other words, there are no limitations. #

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Plastic piping systems

Plastic pipe is of interest to the chemical industry essentially for one reason—economy. This means economy in first cost, maintenance cost, or both. Here is a review, from one consumer's viewpoint, of the adequacy of available plastics for economic pressure piping systems. The analysis does not include detailed consideration of drainage systems and other low-head gravity systems where the engineering requirements may be less exacting.

Comparison of the major plastics in terms of use limits, availability of component parts, availability of design data, and installation methods will show comparative economics in perspective against total requirements of any installation.

In considering requirements for plastic pipe, it must not be overlooked that a piping system includes pipe, joints, fittings, flanges, and valves. For economy, all components must be available in compatible dimensions to provide maximum strength and minimum labor for assembly. It is against this basic concept that materials must be compared.

Materials considered are:

Unplasticized polyvinyl chloride (PVC), Type I, normal impact and Type II, high impact.

Acrylonitrile-butadiene-styrene copolymers and blends (ABS).

Polyethylene, branched and linear.

Epoxy resin, glass reinforced.*

Saran-lined steel.

Steel lined with extruded TFE fluorocarbon resin.**

Chemical resistance

Type I PVC has broad range chemical resistance to mineral acids, bases, salts, and many organics. It is attacked by chlorinated and aromatic solvents. Type II PVC has a lower order of resistance.

ABS plastics have the same spectrum of chemical resistance as PVC, but in lower concentration of acids, particularly oxidizing, are roughly equivalent to Type II PVC.

Glass-reinforced epoxy resin piping resists mineral acids (in lower concentrations than PVC), bases, salts, and most organic materials. It has useful resistance to many solvents which attack PVC.

Polyethylene has chemical resistance similar to PVC. It may be used where solvents are present in the solutions being handled, since swelling rather than dissolution is the general reaction. Certain solvents produce stress-cracking. Resistance to stress-cracking varies considerably with the particular polyethylene, maximum resistance coming with the proper relationship of melt index, density, and molecular weight distribution for each type of resin.

Saran-lined steel is generally similar to PVC in chemical resistance. Saran has better resistance to most solvents.

TFE fluorocarbon resin is attacked only by molten alkali metals, fluorine, and certain fluorinated chemicals.

* "Fibercast," Fibercast Co., Sand Springs, Oklahoma.

** "Teflon," registered du Pont trademark.

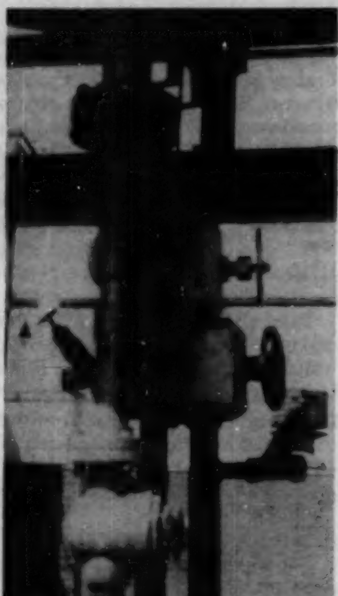

Figure 1. Closeup of PVC piping and valves in chemical plant.

Temperature limitation

All plastics are subject to creep and stress rupture at ambient temperature. It is the load carrying ability, or allowable stress versus temperature and time, that determines the upper temperature limit of usefulness in most cases.

After making allowance for deterioration in chemical exposure, allowable stresses usually limit material to the upper temperature shown in Table 1. Lower limits are essentially arbitrary and are related to brittleness.

Availability

PVC is available in iron pipe sizes (IPS) ½-in. through 6-in.; nominal 20-ft. lengths; with a complete line of socket-type cement fittings and flanges. Valves ½-in. to 4-in. are avail-

Table 1. Temperature limits—°F.

Material	Upper Limit	Lower Limit
PVC, Type I	150	0
PVC, Type II	130	0
ABS	160	0
Polyethylene, low density	130	– 40
Polyethylene, high density	150(?)	– 40
Epoxy-Glass	250	0
Saran-Lined Steel	200	– 20
TFE-Lined Steel	450	–100

able in ball-type; ½-in. to 2-in. in Y-globe, plug, diaphragm, spring check, and ball check.

Threaded fittings to 4-in. IPS also are available. However, threads reduce pressure rating, increase cost for making a joint, are sources of easy breakage, and tend to leak when temperatures cycle above about 120°F. They will not be considered further in this article.

ABS is available in the same pipe sizes as PVC and also in the SWP (solvent-weld-pipe) dimension. Only IPS size is considered here. Socket cement fittings are limited to 2-in. and under. Larger sizes are threaded, or a combination of threads and flanges. Diaphragm and ball valves are available.

Low-density or branched polyethylene may be obtained to 6-in. diameter in series I dimensions; to 2-in. diameter in series II and III dimensions. The series are for different pressures and reflect an increasing wall thickness (*1*). Pipe to 2-in. diam. comes in coils of 400 to 150 ft., depending on diameter. Fittings are of the insert type for sizes 2-in. and under. They are normally available in high impact styrene, ABS, and nylon. Pipe sizes larger than 2-in. use welded-on flanges and fabricated fittings. Valves are special.

Linear or high-density polyethylene is available only in the series I dimension to 2-in. diam. The same fittings are used as with low-density pipe.

Epoxy-glass pipe has a limited size range, 2-in. to 4-in., with IPS O.D. and nonstandard wall. Standard length is 20-ft. nominal. It is available in three weights or wall thicknesses. Socket, threaded, and flanged fittings are available, but no valves.

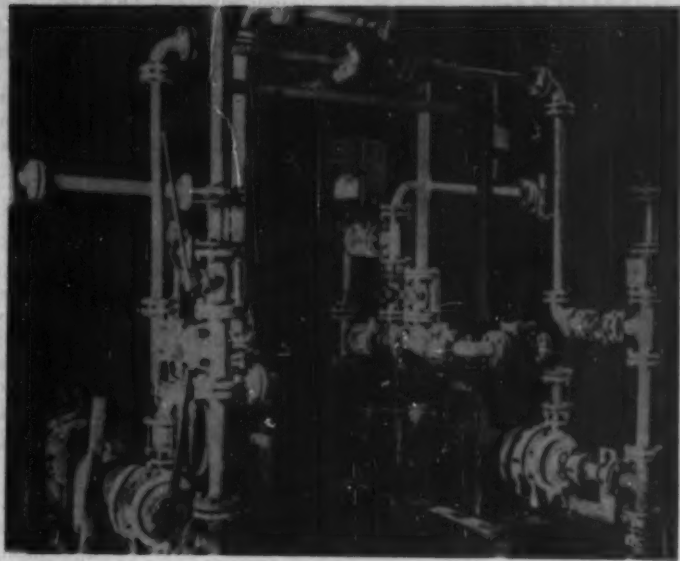

Figure 3. Details of a TFE fluorocarbon-resin-lined pipe installation.

Saran-lined steel is available in 1-in. to 8-in. sizes in IPS O.D. Nominal length is 10 ft. Fittings are threaded union type or flanged. Plug, diaphragm, and check valves are standard. Two sizes of saran-lined centrifugal pumps are also available.

TFE resin-lined steel pipe is flanged only, available in sizes 1-in. to 6-in. IPS, and maximum length 10 ft. Tees, elbows, and reducing flanges or couplings are available in the full size range. No valves are available as yet.

Design data

Basic engineering data are necessary for design of the system if materials are to be used with confidence. Data needed include stress to produce rupture, and stress to produce creep for times up to 10 years and for the entire useful temperature range of a material. The strength of joints must be known in the same terms. The data themselves must be available—not someone's interpretation—because the designer must be in a position to apply safety factors appropriate to the intended service. It is the designer who is responsible for the adequacy of the system.

Other data required include support spacing for different sizes and schedules of pipe that will limit sag between supports to *known* values, Table 2. These data are among the most important—and must be accurate—because the cost of supports can be the deciding factor in many installations. For underground systems, the type trench, depth of bury, backfill, and effect of concentrated loads must be known. Practical methods of accommodating thermal expansion and contraction are required.

For PVC (*2*), ABS (*3*), and low-density polyethylene (*4, 5*), considerable basic data are available. For saran-lined steel and TFE-lined steel, allowable stresses are determined as for comparable steel systems. For high density or linear polyethylene (*4*) and epoxy-glass (*6*), data are in various stages of development.

In no case have the data been reduced to national standards of acceptability such as ASTM and ASA, or ASME codes. Until such standards

Table 2. Deflection vs. span.

Pipe Conveying Water at 75 Lb./Sq. In.
10,000 Hour Test

Span (Ft.)	Temp. (°F.)	Deflection at Center of Span — (In.) PVC – I 2 in. Sched. 80)	ABS 2 in. Sched. 80)	Polyethylene (Series III)
4	80	—	—	1/16
	115	1/16	1/8	1/4
	150	3/16	1/8**	1/16***
6	80	1/16	1/16	1/8
	115	1/8	3/16	3/8
	150	1/2*	3/16**	1/2***
8	80	1/8	3/16	1/2
	115	3/16	5/16	7/8
	150	3-3/4	1/2**	1***

* *2,000 hr.*
** *3,500 hr.*
*** *2,000 - 4,000 hr.*

NOTE: *Data developed at the Engineering Research Laboratory, Engineering Department, du Pont Company.*

Plastic piping

Figure 2. PVC piping, 4-in. diameter.

become available, each designer must satisfy himself as to the adequacy of a system on the basis of his own calculations.

For our own use, company standards have been developed for purchasing and installation to insure adequate quality. Standard design stresses also have been developed.

Economics

Over-all economics are dependent on total cost for a particular installation. Pipe size is important, as is complexity of the system with respect to number and type of fittings and availability or cost of required supports. These and other variables make impossible an absolute statement of relative cost of materials. Each particular system must be evaluated.

Considerations vary for systems of different diameter. In 2-in. piping, for which all the materials are available, the following considerations apply:

1. Relative material cost will be polyethylene lowest, with ABS, PVC, epoxy-glass, saran-lined steel, TFE-lined steel progressively higher in cost.
2. Labor cost for making a single joint will be approximately in the order: polyethylene, ABS, and PVC equal and lowest; TFE-lined steel; epoxy-glass; saran-lined steel highest. Number of joints or fittings will determine cost.
3. Support spacing and hence cost will vary with temperature. Polyethylene requires continuous support at all temperatures; for ABS and PVC, span varies from 8 ft. at 75°F to continuous at 150°F; for epoxy-glass, 10- to 14-ft. support is required; and for saran-lined and TFE-lined steel, it is the same as for Schedule 40 steel pipe. Span varies also with diameter of pipe.

In larger sizes, each consideration must be varied to suit conditions and availability of required components of the system.

Experience

For chemical pressure piping systems, Type I PVC is proving to be the most versatile plastic piping available for general use in the temperature range 0-150°F. Its broad-range chemical resistance, availability of components in wide size range, ease of installation, and reliability, contribute to over-all economy.

Approximately $40,000 were saved in one process application involving about 3,000 ft. of pipe in sizes ⅜ in. to 6 in., with hundreds of fittings and valves, when a Type I PVC piping system was used instead of one constructed of aluminum, stainless steels, and higher nickel alloys.

In another application, PVC replaced rubber-lined steel piping for handling acid slurries at a saving of $20,000. About 5,000 ft. of pipe were involved in sizes to 6-in. IPS.

A survey of ten company plants shows a definite trend to Type I PVC in the thermoplastic pipe field. Typical examples are shown in Figures 1 and 2. Our use index stands at 667 compared with 1956=100. No major use of Type II PVC is contemplated.

Epoxy-glass piping systems have their greatest potential in the pressure-temperature range beyond which PVC becomes unsuitable. They are useful at 150 lb./sq. in. and 250°F. Use at present is small since detailed information on working stresses, support span, and installation methods have been established only recently. Large scale use is expected to develop.

Saran-lined steel occupies a position roughly comparable to epoxy-glass. Its size range is greater, however, and it has been available long enough to determine its use limits and to develop familiarity among pipe fitters. It is still considered primarily for those services beyond the temperature-pressure limits of PVC.

Low-density polyethylene presents an anomalous picture. Excellent pipe resins are available, but pipe of the necessary quality for pressure piping systems is difficult to obtain. This required quality can be insured only by quality-control procedures that include pressure testing all pipe for gross defects and evaluating random samples with a stress-rupture test. Few vendors are equipped for such testing, with the result that the consumer cannot depend on this type of polyethylene pipe for critical service applications.

In one extensive underground water system, numerous failures occurred within one month necessitating replacement. Sections of the pipe, hydrostatic-tested at 45°C, and a hoop stress of 650 lb./sq. in. failed in 26 seconds compared with 100 hours minimum for acceptable quality. Such failures, of which many have been experienced, more than offset the economy of polyethylene in successful applications.

Linear or high-density polyethylene is too new to have obtained wide acceptance. Further evaluation is required to determine its true quality and economy.

ABS piping is used in very small quantity. Socket fittings, which provide strong joints and can be made at low labor cost, are available only to 2-in. IPS, and these have been a recent development compared to PVC. Since ABS also has a lower order of chemical resistance than PVC, it has declined in use as PVC has increased. As a complete line of socket fittings is developed comparable to PVC, and as complete engineering data become available on the new high-temperature ABS material, interest should be renewed because of the lower material cost of ABS.

TFE fluorocarbon resin-lined steel is a high-cost material for severe application where none of the other plastics can be used. It is relatively new, but it is finding use in those services where glass-lined steel and special high-alloy steels are normally required. Our use index is 333 compared with 1956 = 100. In one extensive application involving pipe and fittings 1-in. to 6-in. diam., a monthly saving of $60,000 is being obtained. This is a combined maintenance and operating savings realized through elimination of shutdowns for repairs. Acids and organic solvents are handled at high temperature and pressure. A portion of the system is shown in Figure 3.

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4. Bakelite Company, 30 East 42nd Street, New York 17, N. Y.
5. *Designing with du Pont Plastics*, E. I. du Pont de Nemours & Co., Polychemicals Department, Plastic Sales Division, Wilmington 98, Delaware.
6. Fibercast Company, Sand Springs, Oklahoma.

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Fixed impeller hydroclones

Within the range investigated, it appears that the fixed-impeller centrifugal separator can be used to extend the separation-point range of the liquid-solid cyclone.

The application of the liquid-solid cyclone to many industrial separation processes has been rapid, since it offers many advantages. Among these are: (1) economy in terms of low initial cost and low operating cost, (2) simplicity—it has no moving parts, (3) high capacity per unit of floor space, and (4) sharp separation at fine-particle sizes (*1-10*).

Experimental studies have been conducted concurrently with the applications for the liquid-solid cyclone to determine design and operating factors for increasing its application and usefulness. Several investigators have presented results of detailed studies permitting the accurate design of separators for specific applications. (*1, 2, 3, 6, 12, 13, 14, 15, 16*). These investigators have also pointed out some of the limitations of the liquid-solid cyclone. Dahlstrom (*3*) has indicated that for certain applications the separation point needs to be raised to a higher micron size. It has also been demonstrated that as the separation point is increased by manipulation of variables, the sharpness or separation decreases for the cyclone.

* *Deceased*

Because there are many operations in the mining, chemical, and agricultural fields where the separation desired is beyond the range of the cyclone, as presently designed, it appeared desirable to develop a device which would extend the range of operation of the cyclone. Furthermore, because the cyclone had been successfully employed in certain industrial applications, it was reasoned that the principles embodied in the cyclone, with its resulting simplicity, would be a good starting point for developing a device to extend its range of sharp separation to large-particle sizes.

Design features

With these considerations in mind, the authors proposed a fixed-impeller centrifugal separator. This separator, Figure 1, embodies a fixed impeller, an overflow pipe with bottom discharge concentrically located in the device, and a break or baffle plate. The impeller was incorporated as a means for providing the whirl velocity necessary for the vortex. The overflow pipe with bottom discharge was included in place of the overflow pipe with top discharge used in conventional cyclones. This was done be-

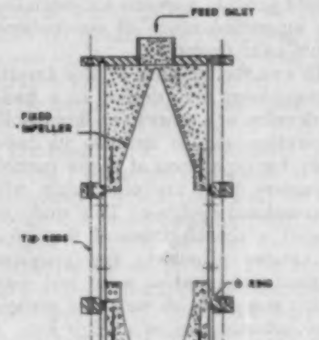

Figure 1. Assembly drawing of $5\frac{1}{2}$-in. fixed-impeller separator.

Hydroclones

continued

cause it appeared that such a design would provide lower energy loss. The break plate was placed in the device to act as a false bottom, and for secondary vortex control.

If a slurry of solid and liquid were introduced at the top of the device, it would flow down through the blades of the impeller. The mixture would receive a whirl velocity, which would be a function of the initial velocity striking the blades and the blade angle. The resulting whirl would set up a vortex for separation. The overflow with a small amount of solids would discharge out the overflow pipe, and the underflow with high-solids concentration would discharge out the underflow pipe. The lower energy loss (with the overflow pipe discharge out the bottom) and the added variable of impeller design should provide a means for extending the separation range of conventional liquid-solid cyclones.

It was the purpose of this investigation, using this device as a basis, to develop equipment for liquid-solid separation and to indicate its feasibility for separation at larger particle diameters than are obtainable with conventional cyclones. This study included a consideration of the effect of various geometric and operative factors on separation point and separation sharpness, as well as a preliminary investigation of energy loss. It was concluded that several of the variables involved with the fixed-impeller device should be the same as some of the important variables of the liquid-solid cyclone. Dahlstrom (3) has shown that an equation of the following form is applicable to conventional cyclone operation at and

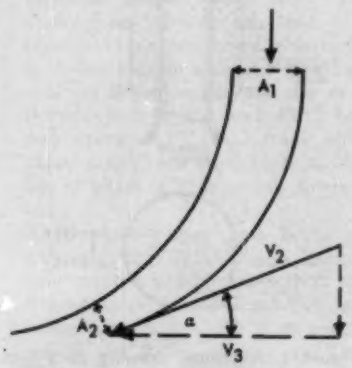

Figure 2. Blade-velocity vectors.


Figure 3. The 5½-in. impeller.

below a feed concentration of 15% solids by weight.

$$\mu = \frac{K\,(eb)^a}{Q^c}\left(\frac{T}{\rho_s - \rho}\right)^q \qquad (1)$$

where μ = particle size (microns) at 50% point (particle size which reports 50% by weight to underflow and overflow).

It should be noted that classification efficiency, according to Dahlstrom, is a function of centrifugal force, e, b, and Q in Equation (1), and specific gravity of particle and slurry. Thus, if e, b, and the physical properties of the system are fixed, classification efficiency varies inversely with the flow rate raised to the proper power. A similar equation could be assumed for the fixed-impeller device; however, a different term corresponding to the inlet-nozzle diameter would have to be included. One approach is: Take a section of the fixed impeller, *i.e.*, two blades with an entrance velocity at the blade equal to V_1, entrance area equal to A_1, discharge area equal to A_2, and discharge velocity equal to V_2, Figure 2. By proportion,

$$V_2 = \frac{V_1 A_1}{A_2} \qquad (2)$$

Then, whirl velocity =

$$V_3 = V_2 \cos\alpha$$

$$= V_1 \frac{A_1}{A_2} \cos\alpha \qquad (3)$$

Thus, the whirl velocity, V_3, could be calculated as a function of blade angle and entrance velocity. Because it is convenient to represent the effect the overflow nozzle has on centrifugal force in terms of diameter, it is desirable to express V_3 as some equivalent round pipe diameter, D_R or

$$V_3 = \frac{4\,Q}{\pi D_R^2} \qquad (4)$$

where Q = volumetric flow rate (VA) and

D_R = equivalent round pipe diameter to give a velocity V_3 for a flow rate Q.

Then

$$D_R = \left(\frac{4\,Q}{\pi\,V_3}\right)^{0.5}$$

$$= \left[\frac{4\,Q}{\pi V_1\left(\frac{A_1}{A_2}\right)\cos\alpha}\right]^{0.5} \qquad (5)$$

or, by continuity,

$$D_R = \left(\frac{4\,A_2}{\pi\cos\alpha}\right)^{0.5} = b \qquad (6)$$

Then, the assumed Equation (1) for the fixed-impeller device becomes

$$\mu = \frac{K_1\left[e\left(\frac{A_2}{\cos\alpha}\right)^{0.5}\right]^a}{Q^c}\left[\frac{T}{\rho_s - \rho}\right]^q \qquad (7)$$

This indicates that if the blade angle, the other geometric variables, the physical properties, and operating conditions of the system were fixed, an investigation of the overflow diameter as a function of flow rate should characterize a, c, and K_1. Also, by investigating different physical systems of solid and slurry density, T and q should be evaluated.

A plot of μ vs. $$\frac{\left[e\left(\frac{A_2}{\cos\alpha}\right)^{0.5}\right]^a}{Q^c} \qquad (7a)$$

with log-log coordinates should yield a straight line for a given geometry and set of operating conditions. As the geometry and operating conditions of the system are varied, K_1 should

change, but a and c should remain constant. To determine variations in the value of K_1 for a given impeller, it would be necessary to consider various geometric and operating variables.

Intuitively, one would expect the following to have significance: (See Figure 1.) (1) diameter of the test section, (2) diameter of the break plate, (3) position of the break plate with reference to the top of the overflow pipe, (4) length of the section between the impeller and the bottom section, (5) distance between the top of the overflow pipe and the impeller, (6) concentration of solids in the feed, and (7) concentration of solids in the underflow, which is also related to the volume split between overflow and underflow.

Since in a vortex, centrifugal force has been shown to be proportional to the square of the velocity divided by the radius of curvature, the diameter of the device should have an effect on operation. However, investigators (*11, 17*) have shown that diameter has a negligible effect on classifiication size and energy requirements (*2, 3, 6*) of the cyclone.

In view of the similarity between the cyclone and the fixed-impeller device, it was assumed that the effect of diameter on classification and energy requirements was probably not significant for the fixed-impeller separator.

Criner (*11*) has shown that in a vortex, particles are moved toward the core by a radial velocity V_r but are retarded by the centrifugal acceleration $\frac{V_t^2}{r}$ where V_t is equal to tangential velocity and r is equal to the radius. A particle of a specific size acted upon by V_r and $\frac{V_t^2}{r}$ would "find" a radius at which the velocity of settling equaled V_r.

The circle formed by this radius is referred to as the equilibrium radius. Particles of other sizes would find other radii—larger particles nearer the periphery and smaller particles nearer the core.

This mechanism would provide a series of concentric strata of particles, each stratum containing a range of particle sizes. Thus, it would appear that the diameter of the break plate would affect separation, since it would select which stratum to pass to the underflow and which to turn upward toward the overflow outlet.

Since the source of the fluid is at the periphery of the vortex, there must be a radial velocity, V_r, imposed upon the vortex motion. The radial flow carries energy to the inner area of the vortex to replace that dissipated through turbulence. This energy thus transported is used to maintain the strength of the vortex. Criner (*11*) has shown that V_r can be considered independent of axial position in a vortex. Therefore, it would seem that the radial flow along the axis would be constant per unit area, and the total flow to the core would be proportional to the length of the vortex along the axis. Consequently, the distance between the impeller and the top of the overflow pipe and the length of the section between the impeller and the bottom plate should affect the separation characteristics of the device.

The discussions above are concerned with the primary, or main vortex of the system, which is the primary factor in the operation of the system when the break plate is at the same level as the top of the overflow pipe. When the break plate is moved a finite distance below the overflow outlet, a secondary vortex is created around the outside of the overflow pipe. This vortex should turn in the same direction as the main vortex, but its vertical velocity component is turned in the upward direction, or opposite that of the main vortex. All other factors being fixed, the classification size should vary inversely as some function of the distance between the break plate and the overflow outlet; that is, as the distance is increased, the size of separation of the particles should decrease. This would appear reasonable when it is considered that the secondary vortex would provide a second chance for particles to be exposed to a centrifugal separation force.

The concentration of the solids in the feed should affect the separation point because if high enough concentration is used, hindered settling effects due to crowding of the particles should be evidenced. However, investigations (*2, 3, 6*) have been reported which show that hindered settling effects are negligible at or above a feed-volume ratio of eight parts of liquid to one part of solid. Since no quantitative expressions are known to be available, it was decided to investigate the effect of feed concentration on separation size for the fixed-impeller device.

Dahlstrom (*3*) investigated the effect of concentration of solids in the underflow in a 9-in. cyclone. He reported that the separation point was decreased slightly with an increased volume to the underflow. This could have a greater affect on separation, since liquid with its accompanying fine solids would be taken from the overflow and discharged in the underflow. Conversely, the minor effect appears feasible when it is considered that no greater centrifugal force should occur with higher volume splits to the underflow. In the fixed-impeller device, the presence of the break plate could considerably modify the general situation found in a cyclone. As the volume split is increased to the underflow at a specified rate, the volume of material turned from the primary vortex toward the overflow outlet could be decreased.

The equation as assumed earlier should define the classification point and the following relationship should define the sharpness of separation.

$$\text{Percentage of coarse-particle separation} = \left(\frac{W_r}{W_c}\right)100 \quad (8)$$

and

$$\text{percentage of fine-particle separation} = \left(\frac{W_o}{W_f}\right)100 \quad (9)$$

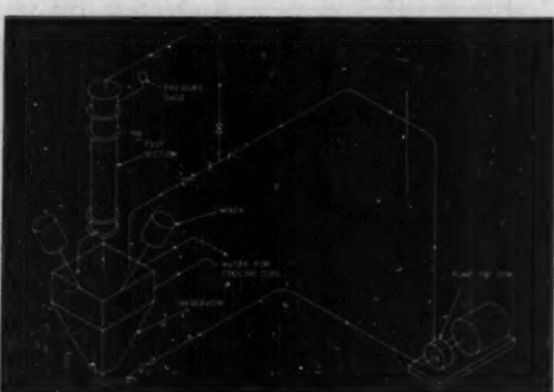

Figure 4. Diagrammatic sketch of equipment setup.

continued

Hydroclones

continued

Thus, if equations of the type assumed were true, it should be possible to define the separation point and the sharpness of separation.

Equipment

To facilitate construction and provide flexibility for experimental study

Notation

a	Constant in Equation (1)
b	Inlet diam., in.
c	Constant in Equation (1)
D_R	Equivalent round pipe diameter to give a velocity V_3 for flow rate Q
e	Overflow diam., in.
F	Energy loss, feed
G	Flow rate, lb./sec.
GPM	Flow rate, gal./min.
h_L	Head loss, feed
K	Proportionality constant, Equation (1)
K_1	Proportionality constant, Equation (7)
Q	Flow rate, cu. ft./sec.
q	Constant in Equations (1), and (7)
T	Constant in Equations (1), and (7)
V	Tangential velocity
V_1	Velocity at blade entrance
V_2	Velocity at trailing edge of blade
V_3	Whirl velocity
V_r	Radial velocity
W_c	Weight of solids greater than the 50% point in feed
W_f	Weight of solids less than the 50% point in feed
W_o	Weight of solids less than the 50% point in overflow
W_v	Weight of solids greater than the 50% point in overflow
μ	Particle size in microns at the 50% point (point at which a particle of specific size reports equally by weight to the overflow and underflow)
α	Blade trail edge angle
π	Constant (3.1416)
ρ	Density of slurry
ρ_s	Density of solid

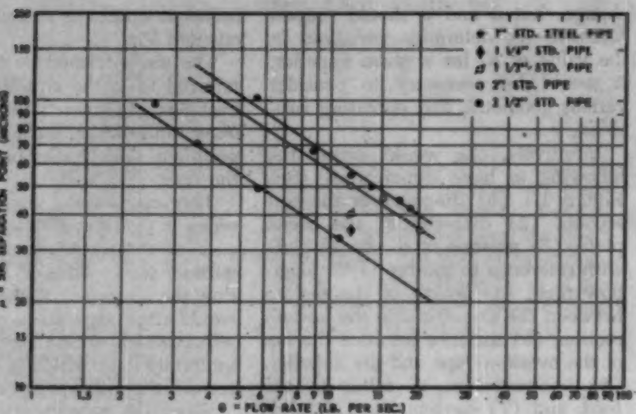

Figure 5. 50%-point vs. flow rate.

it was decided to use a 5½-in. diam. as the design diameter for the test section. This permitted the use of both 6-in. plastic and steel tubing with a 0.25-in. thick wall. Because geometric variables were to be studied, the test section was designed using "doughnut" flanges with recessed O-ring gaskets. The sections of the tubing would then be held in place between two flanges by four 0.25-in. tie rods; sections above and below would be held in place similarly. This arrangement permits rapid change in length of test section or change from plastic to steel by manipulation of tie rods.

Bottom plate and discharge assembly. Since the overflow diameter would have to be varied over a convenient range, a bottom plate was designed to provide the necessary flexibility.

Impeller design and construction. It seemed necessary to design a blade which would gradually accelerate the liquid and eliminate any free-flow area, particularly near the center of the section; however, design would have to be simple enough to be constructed economically. With these conditions in mind, it was decided that perhaps the simplest shape would be that of an arc of a circle contained in an annulus. This shape would produce a gradual whirl or acceleration of the liquid, and would be relatively simple to lay out and build. It would also permit the elimination of free-flow area, and, because of the annular construction would give a higher whirl velocity; it should also eliminate short-circuiting. Since final design for hydraulic impellers necessitates an empirical approach, it was decided to design, construct, and test an impeller using blades based on the arc of a circle. Modifications could then be made in blade design, if necessary. Relationships were developed for considering the essentials of blade construction (*i.e.*, the trailing edge angle, the blade length, the distribution of curvature, and blade thickness). The

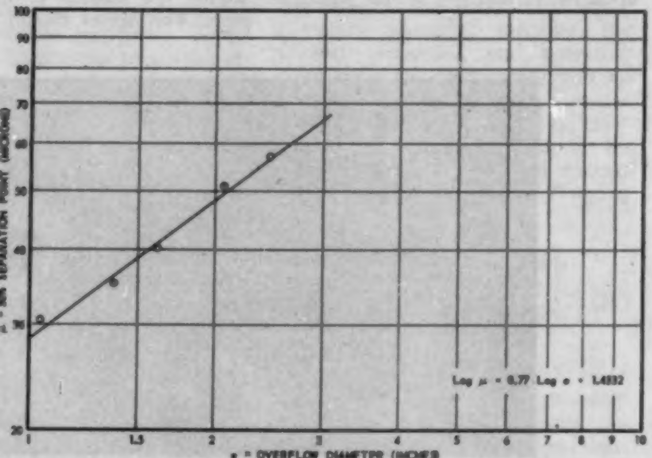

Figure 6. 50%-point vs. overflow diameter.

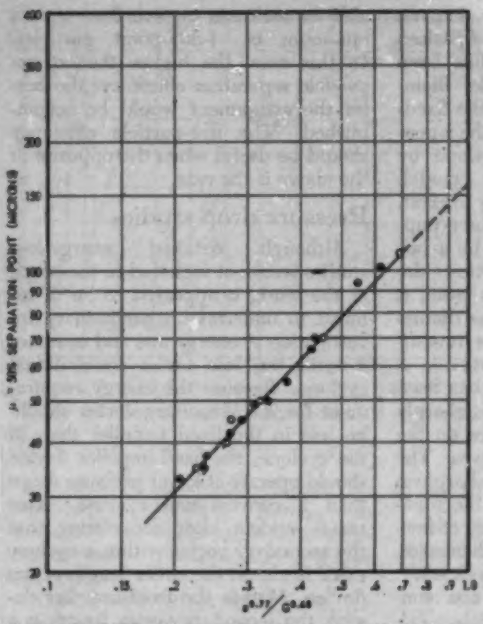

Figure 7. 50%-point vs. correlation coefficient.

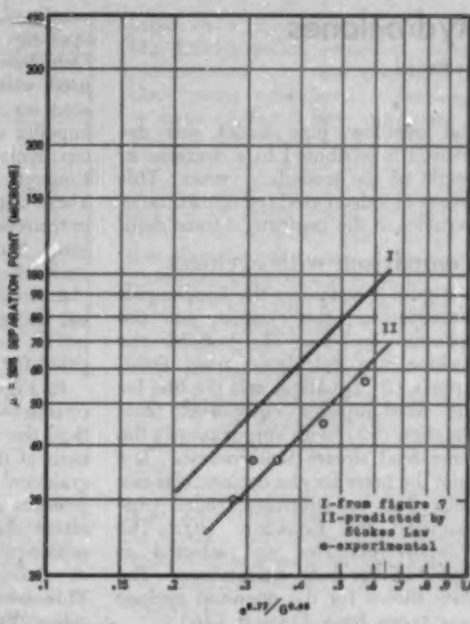

Figure 8. Effect of solids density on 50%-point.

impeller, designed according to these relationships, was held within the tubing section by means of rolled pins (0.0625-in. diam. and 0.5-in. long). The pins were placed in holes drilled through the outside tubing into the edge of the blades. The completed impeller is shown in Figure 3.

Separation investigation. A diagramatic layout of the experimental setup is shown in Figure 4. Slurries of sized sand, density 2.63 g./cc. and barytes, density 4.42 g./cc. were used in this work.

Overflow diameter as a variable. Earlier it was pointed out that on the basis of Equation (7), an investigation of the overflow diameter as a function of flow rate should characterize three of the constants of that equation. Consequently, four runs were made to obtain the relationship between flow rate and overflow diameter. The geometry of the test section was fixed with the exception of the overflow-pipe diameter. Figure 5 is a plot of 50% point vs. flow rate with overflow diameter as a parameter. These data indicate a family of straight lines with slope (calculated by method of least squares) of 0.68. The 50% point vs. overflow diameter is plotted in Figure 6. A straight line can be fitted to these points by least-squares method with slope 0.77. Since both overflow diameter and flow rate vary as a log function of the 50% point, it appeared that a correlation coefficient should exist as a function of the 50% point. The results are plotted to log-log coordinates in Figure 7.

From Figure 7 it is apparent that the data can be represented by a linear relationship with a slope of 1.00, and intercept 157 calculated by the method of least squares. Thus,

$$\mu = 50\% \text{ point (microns)}$$

$$= 157\,\frac{e^{0.77}}{G^{0.68}} \qquad (10)$$

Effect of solids density. Since it appeared that the solids density should be investigated, barytes was substituted for the sand. Figure 8 is a plot of the results. If Stokes' law applies, then, the diameter ratio of equal-settling-velocity particles of different densities (assuming the same slurry viscosity) is

$$\frac{D_{s1}}{D_{s2}} = \left(\frac{\rho_{s2} - \rho_2}{\rho_{s1} - \rho_1}\right)^{0.5} \qquad (11)$$

If this statement were true, then density parameter lines could be drawn parallel to the base line of Figure 8 and the predicted performance line on the basis of Equation (11). It is apparent from Figure 8 that agreement between predicted and experimental performance is satisfactorily indicated. Combining Equations (10) and (11),

$$\mu = 157\,\frac{e^{0.77}}{G^{0.68}}\left(\frac{1.54}{\rho_s - \rho}\right)^{0.5} \qquad (12)$$

This equation has the same form as assumed Equation (1) with the exception of the blade angle. Since experimental work was performed at a fixed blade angle, the effect of this variable has not been evaluated. It seems logical to assume that the function

$$\left(\frac{A_2}{\cos\alpha}\right)^{0.5} \qquad (12a)$$

(from Equation 7) should vary with the same power as the overflow diameter e. (*i.e.,* 0.77). Using this assumption, it would be possible to predict μ for a given set of conditions.

Effect of other geometric and operating variables. After completing the investigation of the variations of solids density, several geometric and operating variables were investigated. All of these variables had no effect on the exponents of the equation for the 50% point. All resulted in operating lines parallel to the base line, with different intercept points. A decrease in break plate diameter, a decrease in distance between break plate and overflow pipe outlet, increased solids in the feed, and increase in length of the vortex core all resulted independently in an *increased* 50% point. An increase in section length and increased water volume split to the underflow resulted independently in a *decrease* in 50% point. The increase in 50% point when the distance between the break plate

Hydroclones

continued

and overflow pipe outlet was decreased is attributed to a decrease in height of the secondary vortex. This results in a decreased retention time of particles in the centrifugal force field.

Comparison with cyclones

Figure 9 compares the fixed-impeller separator, the cyclone, and the open-top cyclone. The line for the cyclone was calculated from Dahlstrom's (*3*) equation, and the line for the fixed-impeller equipment from equation (*12*), with approximately the same feed stream size analysis. The inlet diameter for the cyclone was calculated as an equivalent round pipe diameter by Equation (6). The overflow diameter was selected as 2.067 in. for both calculations. The data shown for the open-top cyclone was taken from Emmett (*18*).

Figure 10 is a plot of the percentage of a specific particle size in the feed reporting to the underflow vs. the particle size in microns. Data are given for a typical cyclone run from Dahlstrom (*3*), two fixed-impeller runs, and run 117 from Emmett (*18*). The slope and the shape of the curves indicate the sharpness of separation.

From Figure 9 it can be seen that for a specific flow rate, the fixed-impeller device separates at a considerably higher 50% point than a conventional cyclone but lower than an open-top cyclone. In this comparison Dahlstrom's (3) equation has been used with overflow and inlet diameters equivalent to those of the fixed-impeller device. However, the open-top cyclone data were obtained by Emmett on a 30-in. diam. model. These data were included for interest, but, in view of the size of the equipment, it does not appear to be a fair comparison. Since completing the planned investigation of this work, it has become apparent that the diameter of the device should be investigated for its effect on separation.

In Figure 10 the cyclone has been considered to separate more sharply than the fixed-impeller device on the basis of the slopes of the curves. The graphical representation of sharpness presents a better picture of the separation sharpness than either coarse-or-fine-particle separation efficiencies, as defined, or Taggart efficiency. This seems evident when one considers that the Taggart efficiency calculated for the cyclone data of Figure 10 is equal to about 75%, whereas this efficiency for the fixed impeller separator is equal to about 73. The coarse-and-fine-particle separation efficiencies for the cyclone run have been calculated to be 93.5 and 82.4, respectively, whereas these same efficiencies were 98.50 and 69.90 for the fixed-impeller separator. However, the coarse-particle separation efficiency, as defined, should be useful for applications where it is desirable to maintain an overflow with a minimum of +50%-point particles. In this case, the higher the coarse-particle separation efficiency, the better the assignment would be accomplished. The fine-particle efficiency should be useful when the opposite of the above is the case.

Pressure drop studies

Although detailed energy-loss studies were not included in the scope of the work, it appeared to be of interest to undertake a preliminary investigation of energy loss and compare it with the loss for a conventional cyclone. Because the energy requirement for the secondary vortex should be less in the fixed impeller than in the cyclone, the fixed-impeller device should operate at lower pressure drops than a conventional cyclone. This seems evident after considering that the secondary vortex within a cyclone extends almost the entire length of the device. Within the fixed-impeller device, the secondary vortex length is a function of the position of the break plate and, by design, could always be less than the length of the secondary vortex of the conventional cyclone.

The energy requirements for the cyclone have been reported (*3*) as

$$\frac{GPM}{F^{0.5}} = K' (eb)^{0.9} \qquad (13)$$

It was reasoned that an additional variable of underflow diameter would

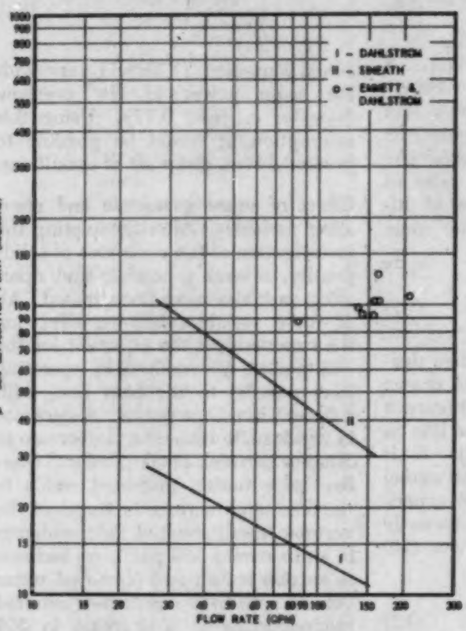

Figure 9. Comparison of cyclones with fixed-impeller separator.

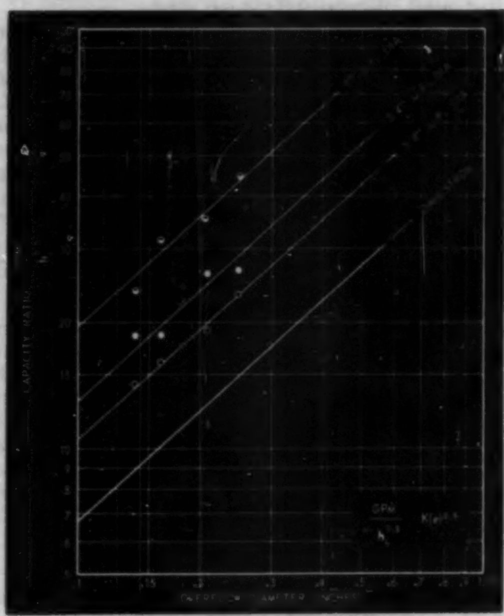

Figure 11. Capacity ratio vs. overflow diameter.

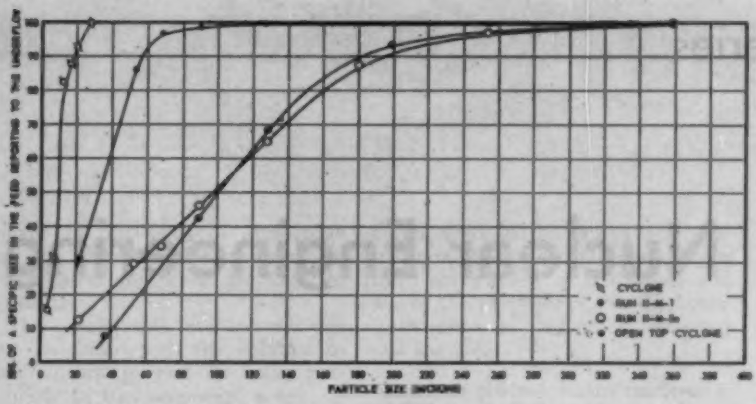

Figure 10. Comparison of sharpness of separation.

have to be considered in studying the fixed-impeller device. Runs were made at fixed blade angle with varying underflow diameter and overflow diameter.

Dahlstrom's (3) capacity ratio was calculated for a conventional cyclone operating at the same flow rate by obtaining an equivalent round-inlet pipe diameter for the impeller device by Equation (6). With Equation (6) as the inlet diameter, the capacity ratio was calculated from

$$\frac{Q}{F^{0.5}} = 5.68\ (eb)^{0.9} \qquad (14)$$

A comparison of the preliminary energy-loss studies with the conventional cyclones as calculated from Equation (14) is shown in Figure 11.

From Figure 11 it appears that the energy requirements for the fixed-impeller device are less than for the conventional cyclone. Another variable, the underflow diameter, must be considered in addition to the inlet and overflow diameters in calculating the capacity ratio for the fixed-impeller device. Since the underflow parameter lines are approximately parallel, a consideration of the intercept of these lines should permit an evaluation of capacity ratio for the device for underflows in the range investigated.

To obtain more generalized relationships for energy loss in the fixed-impeller device, a detailed investigation of this variable as a function of geometric and operative factors will have to be performed. However, in view of the results shown in Figure 11, the reasoning advanced earlier in this work concerning energy loss is sound; that is, because of the overflow discharges out of the bottom of the device, the energy loss should always be lower for the fixed-impeller device than for a comparable conventional cyclone.

Conclusions

The conclusions resulting from the present investigation may be summarized as follows:

1. An equation (12) has been developed for predicting the 50% separation point for the fixed-impeller device with a specific blade contour, blade angle, and for a specific geometry. This equation relates the overflow diameter, the flow rate, and the solid and slurry density to the 50% point.

2. It has been demonstrated that the exponents of this equation do not vary appreciably with geometry. The effect of changing geometric variables is a change in the K_1 value of the equation.

3. It has been advanced that the exponent on the blade-angle relationship of Equation (7) should be the same as that of the overflow diameter, *i.e.*, 0.77. It has been shown that the 50% point increases with decreasing flow rate and increasing overflow diameter.

4. The capacity ratio (GPM/$F^{0.5}$) for the fixed-impeller device is larger than for the conventional cyclone. Thus, as predicted, the energy loss is less for the fixed-impeller separator. Capacity ratio was found to vary (at fixed inlet velocity) with overflow diameter, with underflow diameter as a parameter.

5. For a given flow rate, comparable geometric and operating factors, the fixed-impeller separator produces a higher 50% point than the conventional cyclone. The sharpness of separation, as defined by Taggart and by coarse- and fine-particle separation effciencies defined in this work, was about the same for the two separations. However, a graphical method presented for determining separation sharpness indicates that the cyclone produces a sharper separation than the fixed-impeller separator. Comparison tests with the open-top cyclone were considered inconclusive in view of the drastic difference in size and flow rates of the two devices.

Within the range investigated, it appears that the fixed-impeller centrifugal separator could be used to extend the separation-point range of the liquid-solid cyclone. However, additional work should include:

1. The effect on the 50% point of:
   (a) blade range
   (b) feed volume split
   (c) section diameter
   (d) ratio of overflow diameter to section diameter.
2. A more detailed energy-loss study.

The pursuit of these recommendations and continued development of the fixed-impeller centrifugal separator could well lead to its acceptance into the industrial family of separation equipment.

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CEP Symposium Series

What's in Vol. 55, 1959 No. 22, Part V No. 23, Part VI

Nuclear Engineering

Engineering hot-channel factors, B. W. LeTourneau and R. E. Grimble.
In thermal design of nuclear power reactors engineering hot-channel factors have been established to account for small dimensional deviations from the nominal design of the reactor fuel elements.

Deviations likely to be encountered in practice are described with methods of estimating magnitudes of the effect of each on channel enthalpy rise, film temperature difference, and maximum heat flux.

Examples are given for parallel plate-type fuel elements separated by rectangular coolant channels.

An in-pile study of organics as nuclear reactor coolants, Malcolm McEwen and Edward W. Wiederhold.
A preliminary engineering study to determine the feasibility of using organic chemicals as nuclear reactor coolant moderators. A test loop was designed and operated in conjunction with the reactor at Brookhaven to determine for these organics the specific radiolytic-decomposition rate, gas-generation rate, induced-radioactivity levels, and effect of decomposition products on the operating characteristics of the system and on the engineering properties of each material.

The inside-out reactor, Milan Osredkar and Richard Stephenson.
Describes a reactor design which offers the possibility of obtaining a given thermal flux at a power less than that of a conventional reactor such as the MTR.

Use of a nuclear reactor as a process heat source, R. W. Ritzmann.
Possible methods of using a nuclear reactor as the endothermic-chemical-reaction heat source in a coal-gasification plant. The economics are discussed, and charts showing the effects of steam temperature and heat recovery on the threshold economics are presented. The cost of heat produced by a nuclear reactor is compared with the cost of heat supplied by the conventional method of burning coal with oxygen.

Continuous dissolution of uranium-aluminum fuels in a trickle-type column dissolver, J. C. Bresee, D. L. Foster and E. O. Nurmi.
A continuous column dissolver may be operated with critically safe dimensions, hence this type of dissolver may have an unlimited charge of metal per unit with no theoretical upper limit to the capacity. With the advantage that a continuous dissolver may better serve a continuous solvent-extraction process than a batch dissolver, the continuous column dissolver is potentially the most satisfactory type for short fuel elements or sections of elements.

Design of plutonium processing plants, B. F. Judson.
A design philosophy for plutonium processing plants based upon the experience gained in the operation of a semiworks facility at Hanford Atomic Products Operation. Prime concepts include the use of contamination barriers made of sealed hoods and directionalized air flow, partial separation of operating and maintenance functions in the physical layout, inclusion of multicomponent processing systems in single large hoods, and the considerations necessary for critical mass control.

Radioactivity levels and temperature variations of the Columbia River, Royal E. Rostenbach.
The Columbia River was a prime factor in the selection of the Hanford site for the AEC's water-cooled nuclear reactors. Besides cooling the reactors, the river also serves to dispose of radioactive waste. River water passes through the reactors and large retention basins and is then discharged to the river as a warm radioactive effluent under carefully controlled conditions. This report considers temperature and radioactivity levels of the river.

Studies on X-rays and Bremsstrahlen, L. E. Brownell and E. W. Coleman.
Although secondary radiations may be predicted accurately for very simple situations, such methods are of little value in real situations. The complexity of the problem is apparent if one considers that the production and absorption of electrons and of photons are interdependent processes. This paper discusses briefly some of the factors considered in developing bremsstrahlen sources for medical radiography.

Application of the packed column to the Redox process, E. R. Irish.
A brief description is presented of the Redox process for plutonium and uranium separation and decontamination from fission products contained in irradiated uranium fuel elements. Performance characteristics determined for packed solvent-extraction columns during development work are discussed. Instrumentation for control and observation of performance is described briefly.

Electrolytic recycle method for the treatment of radioactive nitric acid waste, H. W. Alter, D. L. Barney, A. C. Schafer and F. J. Witt.
The bulk of high-level radioactive waste will consist of solvent extraction raffinate. Most of this will be nitric acid containing over 95% of the fission products from the separation process and small amounts of nitrate salts. The first objective in waste treatment is volume reduction of the waste to yield the mixed fission products in a small, high-specific activity package without the simultaneous production of large volumes of low level waste.

Industry's role in university programs of nuclear engineering, D. W. McLenegan.
In training tomorrow's engineers, today's specific problem becomes sec-

ondary to the fields of knowledge and the processes of analysis which this problem and others are likely to demand.

This concept tells how industry can best cooperate with the colleges to their advantage and its own, particularly in the long-range sense.

The subcritical assembly in engineering teaching, W. F. Fagen and Joseph Weil.
The advent of the subcritical assembly has provided university instructors with a versatile laboratory tool which can be used for studying the basic factors involved in reactor design and operation without the hazards produced by criticality. At the same time, measurements can be made within the lattice, and the behavior of the neutrons in environments associated with reactors can be analyzed. In addition, neutrons can readily be detected and measured. Design predictions can also be compared with actual practical measurements.

Radiation source fabrication and handling, Eugene Lamb.
Radiation sources containing greater quantities of separated fission products than are now available will be produced in the Fission Products Pilot Plant at Oak Ridge.

It is expected that much of the plant output will be used in gamma irradiators of intermediate or pilot plant size. Therefore, integrated planning will be necessary from the design of the source unit to its installation in the irradiator. Certain limitations are placed on the source unit by the fabricator's plant the intended use of the source, the characteristics of the fission products in the source, and the method of shipment.

Design and construction criteria for in-pile experimental chemical reactors, D. J. Daniels, M. C. Schroeder, D. D. Foley and R. B. Filbert, Jr.
Use of nuclear radiation in carrying out chemical reactions is now being extensively explored by chemists and chemical engineers. Of the various radiation sources the nuclear reactor is by far the most powerful in terms of intensity of penetrating radiation available, and may be the most likely source of nuclear radiations for chemical processing.

A number of the specific problems encountered in the design and construction of chemical processing loops were not evident at the outset and one of the purposes of this discussion is, therefore, to alert others venturing into the area.

Report on process steam reactors, E. L. Heller and D. O. Hubbard.
The chemical industries require an uninterrupted, reliable, and constant source of heat for their continuously operating processes. In many plants, load factors of 90 to 95% of demand are the rule rather than the exception. Those conditions are ideal for nuclear reactors.

On the basis of recent experience, it is safe to assume that the potential market is 50 to 100 process steam-generator units a year.

Nuclear considerations in design of high-temperature process heat reactors, J. T. Roberts.
Designers of high-temperature process heat reactors must be careful not to rely uncritically on nuclear generalizations based on low-temperature thermal reactors. Differences are reflected in differences in critical size and mass and in control problems associated with temperature coefficient of reactivity and degree of fuel burn-up attainable before processing.

Design of a plant for recovery of uranium by liquid ion exchange (solvent extraction), Kathleen Black and Joseph Koslov.
A process description for the recovery of uranium from sulfuric acid leach solutions by solvent extraction, designed to process 600 tons of ore daily, is presented.

Indirect cycle nuclear reactor system to furnish process heat, R. Carson Dalzell and James P. McGee.
Use of nuclear fission for chemical process heat offers the special advantage of high temperature, limited only by materials of construction. The process heat may be supplied economically at elevated pressures, since no compression of combustion air is required. The major problems are the design of high-temperature fuel elements, construction of an exchanger to transfer heat to process streams in the range of 2,500° F., and development of compressors capable of recycling helium at 1,000°F. and above.

Direct utilization of fission energy for radiation processing, Ward S. Diethorn, Paul Schall, Jr. and G. D. Calkins.
Radiation-induced degradation, polymerization, and synthesis of both organic and inorganic compounds have been reported. High chemical yields in some of these systems suggest the possibility of utilizing radiation sources for the commercial production of chemicals.

If fission recoils could be utilized in a reactor, it would be a highly efficient radiation processing source. The purpose of this paper is to discuss a reactor application of this type.

Experimental determination of dose distribution in the proposed Fir gamma irradiator, B. Manowitz, D. M. Richman, L. Galanter and O. A. Kuhl.
An experimental program to determine the depth-dose distribution in food packages for several gamma irradiator geometries and to examine the nature of aqueous, indium-salt solutions. The experimental results of the irradiator experiments were compared to theoretical calculations of depth-dose distributions and reactor power required for one particular irradiator geometry.

Engineering continuous filtration to the uranium ore-processing flow sheet, C. F. Cornell, R. C. Emmett and D. A. Dahlstrom.
Rapid development of uranium-ore milling has required the solution of several difficult and critical liquid-solids separations. Filtration has been given a large place in the flow sheet in finding these solutions. Filtration theory, test procedures, methods of correlation, and filter construction had to be developed.

High-operating-temperature reactor design, Joseph DeFelice.
The design presented affords a method of immediate entry into the field of high-temperature nuclear reactors for chemical processing. The reactor described is, in essence, a test reactor for the development of high-temperature fuel elements.

continued

Process applications and construction materials for a high-temperature nuclear reactor for chemical pocessing, Leon Davidson and Alfred A. Strasser.
A preliminary study to explore the design and application of a high-temperature process heat reactor.

With known technology a relatively small demonstration reactor could be built in which an insulated central fuel region, running at high temperature, could be used to develop and demonstrate high-temperature components.

The effects of gamma radiation on several polysulfone reactions, Bruce G. Bray, Joseph J. Martin and Leigh C. Anderson.
The advent of the atomic energy program stimulated many research activities to discover uses for the high-energy radiation made available in the fission products of the nuclear reactors. The use of this radiation as a catalyst in chemical reactions has been shown to be very effective in certain cases and may prove to be advantageous on an industrial scale.

No. 23, Part VI

Recovery of radioactive cesium at Hanford, B. F. Judson, R. L. Moore, H. H. Van Tuyl, and R. W. Wirta.
Methods are being developed for recovering radioactive cesium present in high-level waste streams from Hanford's plutonium separations plants. Precipitates would be converted to a stable, radiochemically-pure cesium salt, packaged for shipment as a radiation source.

A survey of the potential market for radiation sources has been initiated to determine whether enough demand can be foreseen for Hanford's operation of a cesium recovery plant.

Control-rod drive mechanism for the Argonne low power reactor, W. J. Kann.
The control-rod drive mechanism for the Argonne Low Power Reactor (ALPR) is a rack-and-pinion type that operates in contact with the primary reactor fluid. The mechanism is located above the reactor, with the pinion drive shaft extending through a pressure-breakdown, collected-leakage seal.

This paper will describe the characteristics of the drive mechanism and its design, development, and testing.

Radiolytic and pyrolytic decomposition of organic reactor coolants, D. R. de Halas.
A rate law has been derived for the combination of radiolytic and pyrolytic damage to organic coolants in a dynamic system. Based on observations of the radiolytic damage in the test loop and of the behavior of the radiolytic tars toward heat, this law provides a simple method of determining the maximum utilizable temperature for an organic coolant.

Some aspects of the use of an organic coolant in a Heavy-Water-Moderated Power Reactor, Malcolm J. McNelly.
Organic materials have been assessed as a possible alternative to the heavy water coolant in a natural-uranium-fueled heavy-water-moderated power reactor. These materials provide scope for appreciable cost reduction in this reactor system.

Studies on characteristics of Savannah River wastes, Bernard Manowitz, C. W. Pierce and Samuel Zwickler.
Laboratory and pilot plant studies were carried out at Brookhaven National Laboratory in support of the Savannah River program on the storage and concentration of liquid wastes.

Vertical temperature distribution, over-all heat transfer coefficients, and foaming characteristics were observed during storage. The foaming and scaling characteristics of low-level wastes were followed for evaluation of waste-concentration criteria.

Blending vs. reenrichment for slightly enriched uranium, Donald Kallman and John E. Brennan.
Although the AEC has contemplated the reenrichment of irradiated but decontaminated uranium, there may be economic advantage to the power plant operator to blend irradiated fuels with highly enriched uranium instead.

Nuclear safety considerations in the storage and handling of fuel elements, Norman Ketzlach.
Calculation methods to determine design criteria for nuclear safety specifications in the storage and handling of slightly enriched fuels are presented. The importance of understanding the reactor theory involved in interpreting results of calculation so that they may safely be applied to plant process conditions cannot be over-emphasized. The importance of standardization of transportation specifications for shipping large quantities of these fuels has also been indicated.

Heat transfer characteristics of polyphenyl reactor coolants, M. Silberberg and D. A. Huber.
In support of the Organic Moderated Reactor Experiment, heat transfer characteristics of several polyphenyls were investigated in a laboratory heat transfer loop. The operating conditions were as follows: fluid temperatures, 480 to 770°F; heater surface temperatures, 565 to 875°F; fluid velocities, 5 to 25 ft./sec.; heat fluxes, 40,000 to 290,000 Btu./(hr.) (sq. ft.); and Reynolds number, 20,000 to 300,000.

Heat transfer correlations obtained by a digital-computer technique are discussed.

Corrosion-screening of component materials for potassium-soda heat-exchange systems, Samuel J. Basham, John H. Stang and Eugene M. Simons.
Sixty-one materials, including high-temperature alloys, pure metals, cermets, and ceramics, which might be useful for special components, in high-temperature sodium-potassium flow systems were screened in tilting-furnace corrosion experiments.

Post-test corrosion evaluations were based on metallographic examinations of the specimens, specimen weight-change measurements, container compatibility examinations, and specimen surface-roughness changes. The materials were divided into three classes according to corrosion resistance.

Boiling pressure drop in thin rectangular channels, N. C. Sher and S. J. Green.
Methods for predicting boiling and nonboiling pressure drop in thin rectangular channels, independently of the void data, have been developed for 2,000 lb./sq. in. abs.

Void data, obtained at Battelle using a rectangular channel at 2,000 lb./sq. in. abs., have been reviewed. These data generally show that the homogeneous model is adequate for boiling at 2,000 lb./sq. in. abs. at qualities above 10%. Techniques for utilizing experimental void data in pressure drop data analyses have been developed.

Abstracts of the contents of Nuclear Engineering, Part VI, will be continued.

Abstracts of other current volumes will also appear soon in CEP.

Optimum solution of many variables equations

Increasing industrial use of mathematics and statistics has pointed up the need for simpler techniques to interpret the equations which arise. Here is a new conceptual approach to this problem. Through this method it is possible to completely characterize—in two dimensions—a class of these equations, regardless of the number of variables. With the ability to examine over the complete range of variables, optimization is readily obtained.

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There is a certain amount of confusion and misunderstanding associated with the concept of optimization. The underlying difficulty is more a question of degree, scope, and technique used, than differences in objective. The most lucid definition of the term "optimum" by Webster is his reference to the biological sciences, "The most favorable condition as to temperature, light, moisture, etc., for the growth and reproduction of an organism." This simplified definition is in reality quite a mouthful. The practical aspects of determining a true set of optimum conditions is in most instances a gargantuan job. However, a close practical approximation to the optimum is another matter.

The concept of optimum conditions is not new. In a sense mankind has always improved and attempted to optimize the world he lives in. What is new is the increasing availability of tools to facilitate the determination of these optimum conditions; these include mathematics, statistics and computing machines. It is the purpose of this article to describe a new technique which offers a significantly broad scope to some types of optimization analysis. However, to put this approach in proper perspective and to make it comprehensible, it is necessary to clarify some of the aspects of optimization.

In broad principle, for a physical problem, optimization analysis means the procedure and study necessary for the determination of conditions which will result in the "best" (economically, physically, etc.) product. In this sense maximization (or minimization) implies optimization, but the reverse is not necessarily true.

For purpose of definition and orientation, consider the hypothetical problem of optimizing the commercial growing of roses. To solve this problem, three distinct phases must be considered:

Definitions: The determination and specification of factors (independent variables) which *might* affect the

Many-variable equations

continued

rose's growth, and the performance characteristics (responses) which serve as the basis for applying the economics of the business.

Examples of these include:

Variable or Input	Response or Output
1—Heredity Factors	1—Number of roses per time period per plant
2—Soil Condition pH Composition (mulch) Trace minerals	2—Quality of texture and coloring of the rose
3—Fertilizer Type (organic) Amount	3—Size of the rose
4—Sunlight (shading, etc.)	4—Leaf growth on rose stem
5—Plant Food Addition Type Frequency Amount	5—Length of rose stem
6—Watering Frequency Amount	

Mechanism: Relating or tying together the relationships and interrelationships of the variables to each of the responses. It is this phase that generates the data or serves as the physical model of the system. To optimize soil conditions for plant growth, it is necessary to specify quantitatively what are the relative effects of different types of soils on growth. Similarly, it is necessary to indicate to what extent rose growth is improved by a higher frequency of plant food addition. The interrelationship (interactions) of the variables on growth are also of importance. Thus frequent watering might be advisable, but not in large amounts.

Optimization: The specifications of the end result (earnings, etc.) to be optimized and the procedure for carrying it out.

In the application of optimization

OPTIMIZATION

A	76.8
B	77.4
C	78.0
D	78.6
E	79.2
F	79.8
G	80.4
H	81.0
I	81.6
J	82.2
K	82.8
L	83.4
M	84.0
N	84.6
O	85.2

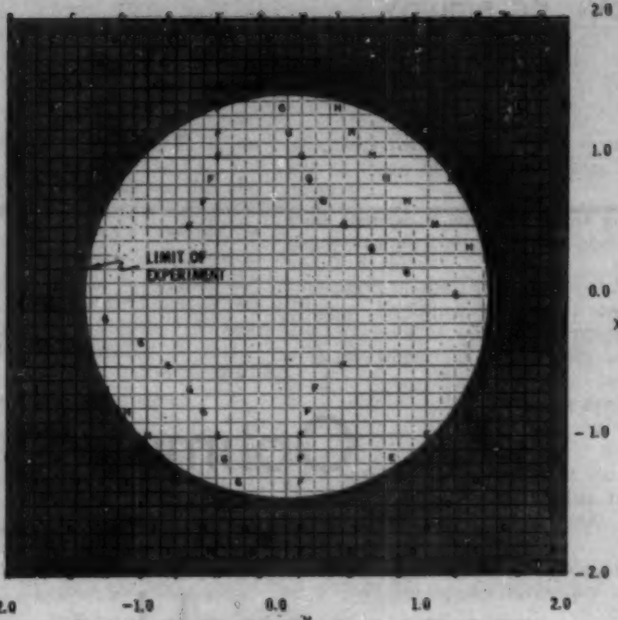

Figure 1. Two-factor response system.

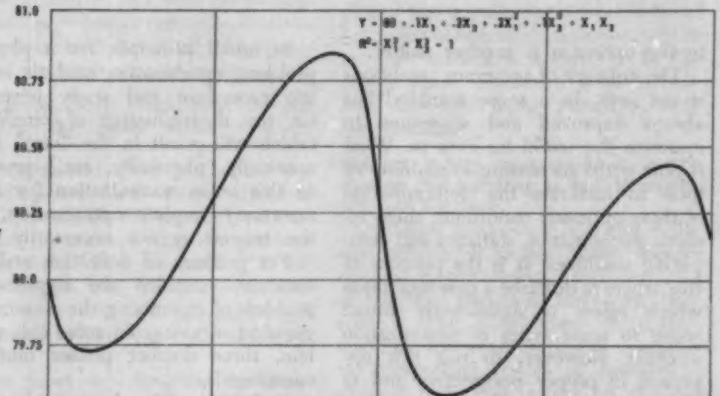

Figure 2. (left) The figure shows the curve plotted for response along unit circle.

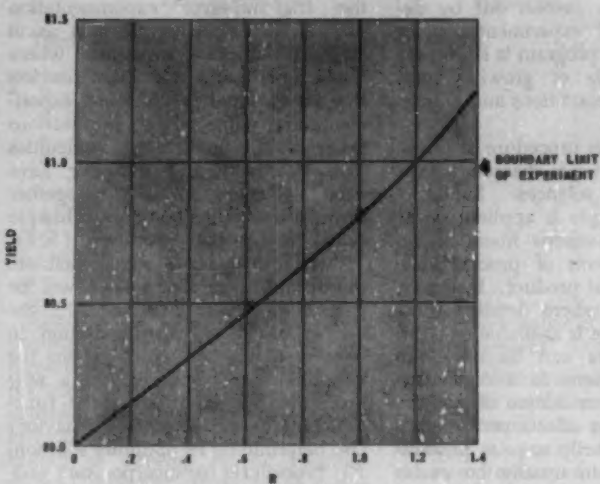

Figure 3. Maximum yield rise from center point.

analysis, the procedure for defining the variables and responses is straightforward. The second phase for the rose problem, includes two alternatives for relating variables and responses:

1. Statistical Design of Experiments (new)
2. Successive Trial-and-error (old)

The relatively-new design-of-experiment approach is the technique for laying out the specific combinations of tests needed as the basis for the optimization. The trial-and-error (intuitive) approach is the classical one involving the selection of a test condition, trial evaluation, and subsequent selection of an alternative condition dependent on whether an improvement was obtained. This is repeated *ad infinitum*. The optimization phase presents an unsolved problem, in the general sense, for the specification of the response to be optimized. What is implied here requires a more philosophical description.

In the rose problem five responses were defined. Each of the variables has some effect on several responses. Obviously, the problem cannot be solved by requiring that each of the responses be simultaneously maximized. The set of variable conditions (frequency of watering, etc.) which results in the highest rose output would not be the same conditions required for best quality and size. Therefore, an economic balance between these responses (relative to their value) is required. This is characteristic of most industrial problems.

Maximization (or minimization)

In defining the factors to be optimized, it turns out that only two basic types can be specified:

1. *Maximization (or minimization) of a single response which is made up of one or more original responses.* The original responses are combined by specified weight factors. For example, a 20% change in rose quality may be worth a 10% change in quantity. (What exact weights to apply to these diverse responses is the unsolved problem for most applications. However, a reasonable balance can usually be estimated.)
2. *Maximization (or minimization) of a single response under 1 above, but simultaneously requiring limits on one or more other responses.* For the rose problem this would occur if only roses with stems at least 12 in. long were commercially valuable.

The computation for the optimization phase covers a wide breadth, from the simple visual comparison of two results to elaborate numerical analysis. The table below summarizes the pertinent considerations described thus far.

Historically speaking, horticulturists experimented (by trial-and-error) hundreds of years ago with the heredity factor to obtain the best coloring characteristic. According to

Three phases to be considered in optimization analysis.

Definitions: Statement of inputs and outputs.	**Mathematical representation:** x_i = Variable i; y_j = Response j
Mechanism: The model used to generate data. The basis on which an analysis can be made.	**Method of generating information:** Experimental statistical trial-and-error (theoretical mathematical basis)
Optimization: Specification and detailed computation.	**Mathematical requirement:** *type* *objective* 1. Maximize (or minimize) y. That is, determining the conditions which result in the maximum number of grown roses only. 2. Maximize (or minimize) y_1 under a restriction that also $y_2 \leq A$. That is, for example, determining the conditions which result in the maximum number of roses with stems at least 12 in. long.

Many-variable equations

continued

accepted definition, this is an optimization approach. Today the scientific approach would be broader, more efficient, and the results more reliable, but with the same objective. This is made possible by the current advancements in techniques within the fields of mathematics, statistics, and computation. However, some of the confusion and misunderstanding in this field is generated by some of the new mathematical terminology as it is applied to the old problems.

To optimize a system, the key contingency is the necessity for determining how the variables affect each of the responses. This in itself is only a means to an end—that is, a means for ultimately improving the final product or obtaining the same product cheaper (or easier). For commercially growing roses it is necessary to determine, for example, what happens to the roses when different amounts of fertilizer are used. This is not only important from the standpoint of improving the crop but it is also necessary as the basis for determining the economic balance of rose growth against fertilizer costs. The point, then, is in estimating what *quantitative* effects fertilizer additions have on the product. With these data the various economic factors can be weighed to determine the optimum solution. Here, the generation of these data involves, basically, only one general procedure—the actual physical growing of the roses. Whether this is carried out by detailed statistical experimentation or just evolves, the program is still based on the principle of growing roses under different conditions and observing the result.

In general, this procedure of physical experimentation is characteristic of the biological sciences. Similarly, this same principle is applied to the processing of synthetic fibers to determine the effects of process variables on the final product. However, in applications where detailed theoretical knowledge is available an alternative procedure can be used. In separating solutions in a distillation column, the determination of how the number of plates affects performance does not necessarily require physical testing. This can usually be evaluated on a theoretical basis which consists of theoretically-derived relationships between the variables and the response—the mathematical model.

In a particular application it might be appropriate to develop the mathematical model from known theoretical relationships or by physical experimentation. The method used is usually dictated by the existing technical knowledge and circumstances surrounding the application. In the aircraft and electronics industries much is known about the mathematical representation of their physical problems. Therefore, functional relationships are used as the basis (model) for the optimization. Conversely, in the chemical industry relatively little is known mathematically in the broad field of reaction kinetics and process behavior. For this reason, a greater use of physical experimentation with statistical reduction of the data is required. Even a modified form of the trial-and-error experimentation can be an efficient tool, such as in large commercial processes where interference with production restricts the use of standard statistical experimentation. For these applications many of the interpretive difficulties associated with trial-and-error have been efficiently pulled together through the application of a technique called "evolutionary operation" (*5, 7*).

Specific techniques which facilitate the optimization of a system will be described. These include: (1) the use of statistical experimentation to develop a function which relates the variables to a response; (2) a new procedure for interpreting the function (and hence the process behavior) and determining its optimum solution; (3) procedures for incorporating various economic factors.

Development of model—statistical experiments

In recent years a new type of statistical experiment especially applicable to optimization analysis has evolved. This is called the Box-Wilson composite rotatable design (*1, 6*). In this approach, a special series of tests are defined. The experimental results of these tests then serve as the basis for developing a simplified mathematical function (which has very convenient properties) to represent the relationships between variables and responses. In addition, other types of statistical experiment (full and partial factorials at three or more levels, for example) also lend themselves to the same general form of the mathematical relation. As an example of how the relationship is developed, a composite rotatable design will be used.

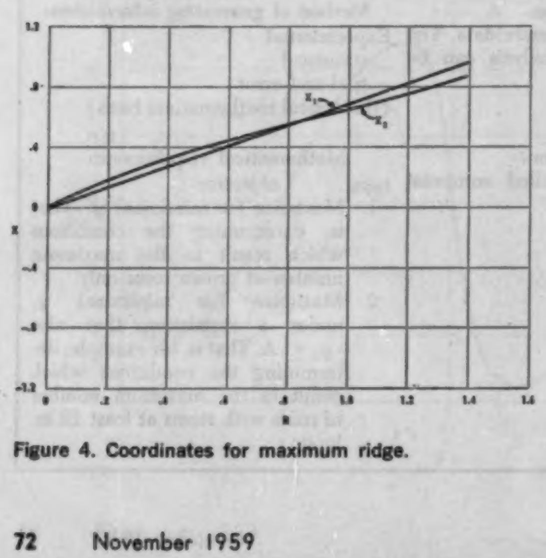

Figure 4. Coordinates for maximum ridge.

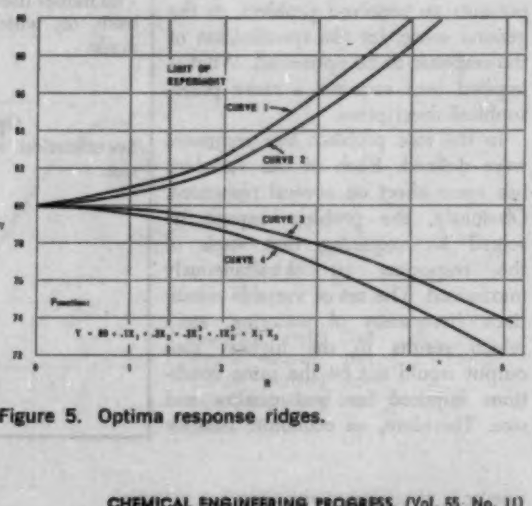

Figure 5. Optima response ridges.

Test	Temperature—x_1 Actual	Temperature—x_1 Coded Values	Pressure—x_2 Actual	Pressure—x_2 Coded Values	y Yield
1	157.3	−1	37.1	−1	To be determined
2	192.7	1	37.1	−1	
3	157.3	−1	42.9	1	
4	192.7	1	42.9	1	
5	150	−1.414	40	0	
6	200	1.414	40	0	
7	175	0	30	−1.414	
8	175	0	50	1.414	
9	175	0	40	0	

Consider a hypothetical reaction process in which it is desirable to determine the effects of temperature and pressure variables on yield. Further, consider that sufficient theoretical knowledge of the reaction is not known to develop kinetic relationships. Under this circumstance a statistical approach would be used. For the purpose of designing the experiments, the operating range of the variables is first specified, thus:

x_1 (temperature) between 150 and 200°F.

x_2 (pressure) between 30 and 50 lb./sq. in.

y (yield) to be determined for each test.

The specific combinations of temperatures and pressures to be tested are now specified by the indicated Box-Wilson experimental design. The number of different levels for each of the variables is always five (regardless of the number of variables). The tests themselves* would be: (above)

For statistical considerations several of the tests would be repeated to estimate experimental error (reproducibility of the tests). Also to facilitate the interpretation of the functional relationship (which is later computed) the values of the variables are coded as shown. Upon the completion of each of these tests the observed yield is tabulated. The results of the experiment are then translated into a mathematical function. The form of this relationship is given by

$$y = b_0 + b_1x_1 + b_2x_2 + b_{11}x_1^2 + b_{22}x_2^2 + b_{12}x_1x_2 \quad (1)$$

where the b values are computed by

* *Specific experiments for different numbers of variables are available in the literature (1, 2).*

the standard method of least squares (3). This is simply a computational method for obtaining the numerical values of the coefficients.

Assume the following relationship has been determined:

$$y = 80.0 + 0.1x_1 + 0.2x_2 + 0.2x_1^2 + 0.1x_2^2 + x_1x_2 \quad (2)$$

where the x values are in their coded form. In addition, it has been confirmed by analysis of variance (3) that the function does accurately represent the behavior of the physical system within the bounds of the experiment (which will be indicated).

The value of this functional form in representing the physical system is several fold:

A. Gives an insight into the relative effects of the variables on yield and their interrelationship effect.

B. Will predict yield for any other combination of variable conditions within the bounds of the experiment which is defined by

$$x_1^2 + x_2^2 \ldots + x_n^2 \leq R^2 = n.$$

Note that the sum of the squared coded levels of the variables for each of the experiments is equal to 2 except for the center point 9.

C. Serves as the basis for determining the optimum combination of variable conditions.

Two additional advantages, which will be developed, are also obtained. These include, first, that an insight into the function's behavior is obtained regardless of the number of variables, and second, that a convenient means for solving the complex Type 2 optimum problem (maximum y_1 such that $y_2 \leq A$) is available. Detailed examination of these aspects requires additional introductory description for reference.

Under item A above, the relative order-of-magnitude of the coefficients for the example given indicates that the effects of temperature and pressure by themselves with coefficients of 0.1 and 0.2 are approximately the same. However, their combined effect, as measured by the unit (x_1x_2) coefficient, is appreciably larger and therefore the dominant term.

For item B, a convenient method of analysis is obtained by plotting the function in a series of contour curves. An example of these contours with a representative series of values of yield are given in Figure 1. The paths of the curves given by the G points, for example, are the combinations of tem-

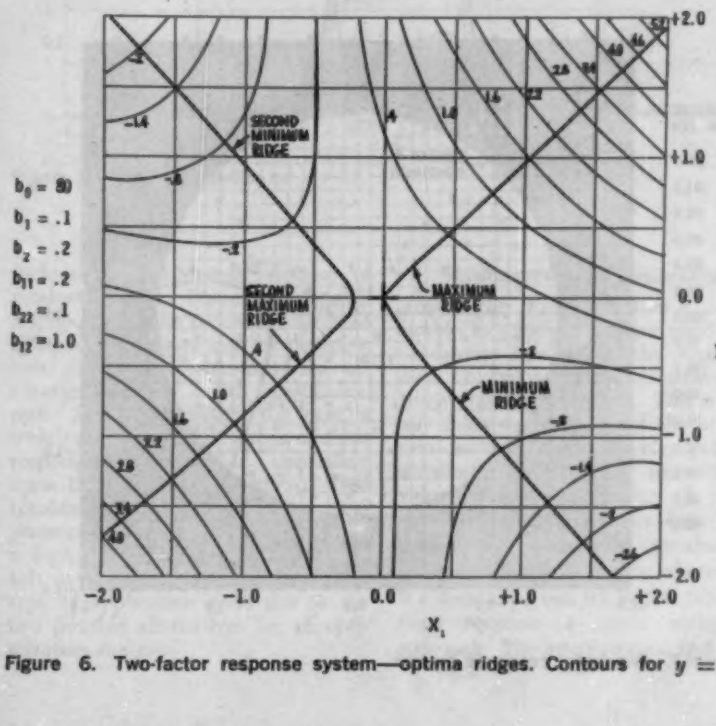

Figure 6. Two-factor response system—optima ridges. Contours for $y = 80$.

Many-variable equations

continued

peratures and pressures which will result in a yield of 80.4%; similarly the H curves correspond to a yield of 81.0%. The points themselves are computed by specifying a yield value, y, and x_2, then solving equation (3) for the two values of x_1.

By analogy to the surveyor's elevation contours, an insight into the yield elevation is thus obtained. The more complex problem involving three variables is obtained by the use of five graphs, one each for $x_3 = -2, -1, 0, +1, +2$ (where the limits of ± 2 are used as a convenience); similarly for the cases of four variables ($5 \times 5 = 25$ graphs) and five variables (125 graphs). Beyond five variables this is no longer a feasible approach and recourse to an alternative analysis is required. This is achieved by considering the various ridges (peaks and valleys) running from the center of the experiment ($x_1, x_2, \ldots,$ equal to zero) to its bounds. This results in a single analysis which simultaneously serves as the basis for all five evaluations.

1. Effect of individual variables on the response.
2. Behavior of response over all combinations of variables.
3. Maximum solution optimization.
4. Insight into response.
5. Multi-response optimization.

Optimization—ridge analysis

Consider the previous two-variable function (2) and for purposes of description assume the yield to be elevation. Suppose we were standing blindfolded on a hillside (the contours of Figure 1) at the position (0, 0) and wanted to reach higher ground with the fewest number of steps. We could feel out with our foot, say 1 unit away, in a variety of directions and note the relative elevations. If a sufficient number of different positions were sampled, these data, plotted as a function of position (x_1, x_2 coordinates) around the circle, would then completely describe the terrain at that distance. An example of how this would look is given in Figure 2.

In addition to the 1 unit circle, we could try ½, 1½, 2 unit steps, and so on. In the case of this hypothetical example the major points of interest are the peaks. That is, the steepest path from the center point. The change in elevation, from the center, can be expressed now as a function of distance from the center. Similarly, the coordinate points x_1, x_2 can also be separately plotted against R if we are interested in the specific location of each peak. Figures 3 and 4 show the elevations and corresponding coordinates of the peaks at various distances from the center. This defines for example that at 1.2 units from the center the maximum elevation is 81.0 which occurs at the coordinate position:

$$x_1 = 0.80 \text{ and } x_2 = 0.78$$

$$(R = \sqrt{0.80^2 + 0.78^2} = 1.20) \tag{4}$$

In terms of our yield problem, Figure 5 includes data for the two peaks and two valleys which are generated. In addition, Figure 6 is a plot of these ridges on the original contour diagram. It is important to note that the secondary peak might be the major significant result. For this problem essentially the same yield can be obtained with the second peak but at significantly lower operating levels of temperature and pressure. Similarly, if the center point of the design had been (− ¾, − ¾) then the secondary peak would have been our primary peak. Therefore, all peaks need to be considered and interpreted. The advantages of this method of interpretation for the more complicated problems now becomes apparent. Thus, an insight into the behavior of our response can be obtained in terms of radius or distance from the center of the experiment—a single-dimensional number. *Therefore, regardless of the number of variables, we are still able to graphically plot and interpret the response in two dimensions.*

The computational procedure for determining the ridges is developed in the computations section.

Optimization—multi-response

At present, it is probably true that in most industrial optimization applications a relatively simplified single response (like yield) is used as the criterion. Actually, however, many of these physical systems have several responses such as product quality and production rate in addition to yield, that is, the Type 2 response optimization previously indicated.

As an example, the previous two-factor yield study might also have

$$x_1 = \frac{-(0.1 + x_2) \pm \sqrt{(0.1 + x_2)^2 - 4\,(0.2)\,(0.1x_2^2 + 0.2x_2 + 80 - y)}}{2(0.2)} \tag{3}$$

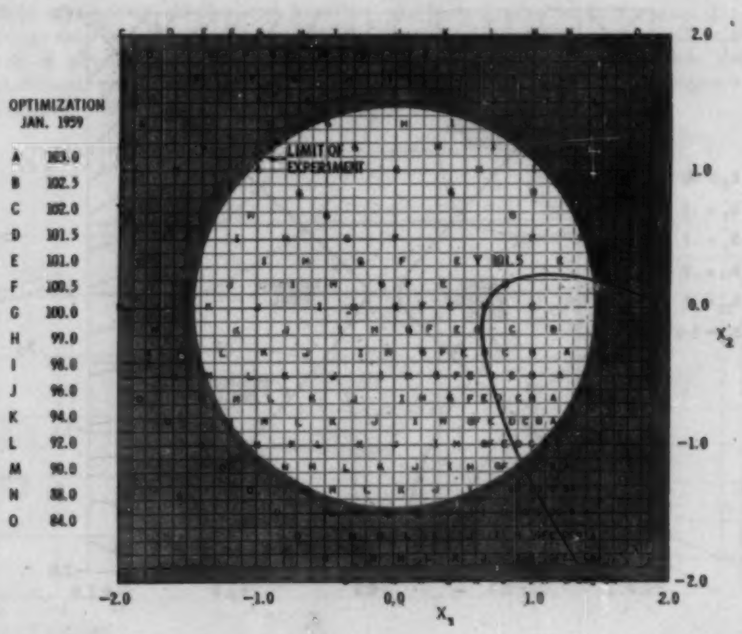

Figure 7. Two-factor response system.

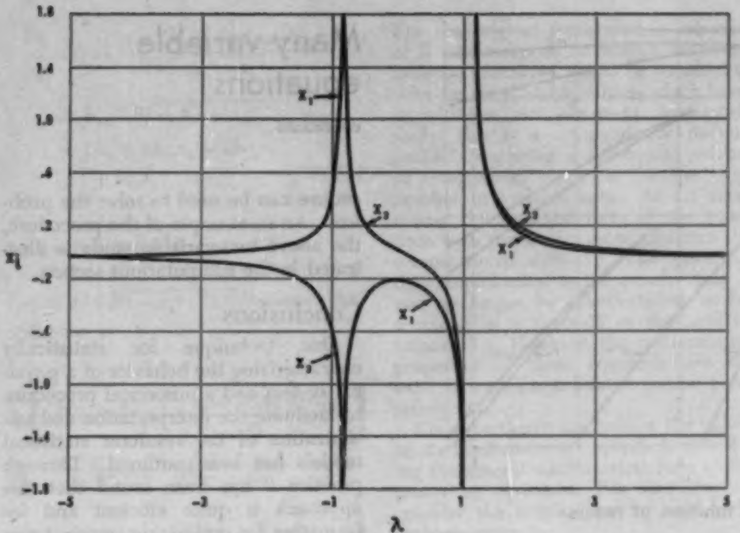

Figure 8. Two factors as function of λ.

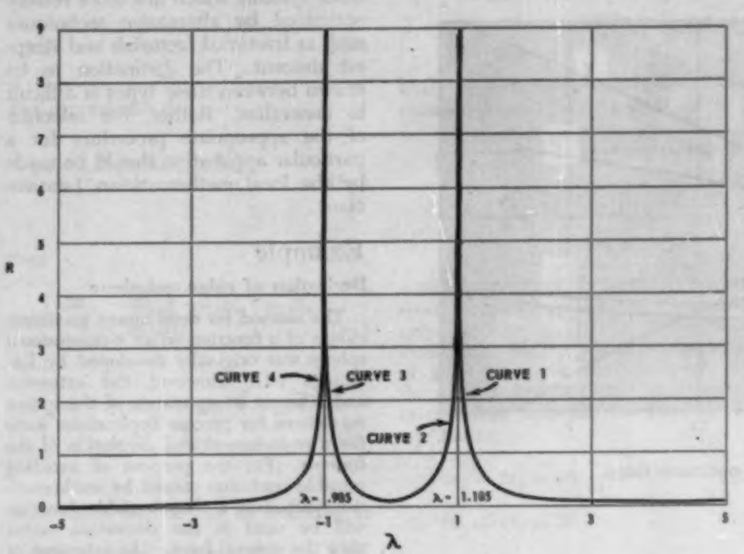

Figure 9. Radii as function of λ.

included an additional response of production rate. Therefore, depending upon how the process is operated in terms of pressure and temperature, two performance characteristics are determined–yield and production rate. And as is usually the case, a wide variety of combinations of these responses are possible depending upon the operating conditions. One combination of temperature and pressure might result in low yield and a high rate while another would result in the converse situation. This type of application gives rise to the two possible alternatives for an optimization analysis:

1. Maximization (or minimization)

This is the situation where it is desirable to jointly maximize yield and production rate. Here, the responses must be combined through some relative weighting procedure. This is usually done on the basis of the economic factors. For example, process economics dictate the incremental value for each percentage of yield, say $A/%. Similarly, sales data help define an incremental production value of $B/unit (the case where this is a decreasing rate for higher productions requires a more elaborate approach. The interpretation and specification of weighting factors for applications in which these numbers can not be accurately estimated is in general an unsolved problem. However, the methods of subjective evaluation are of a major use).

With these economic specifications the new response y_3 is given by combining corresponding coefficients of y_1 and y_2 by the weights.

$$y_3 = Ay_1 + By_2.$$

The problem then requires maximizing y_3 — mathematically the same as the previously outlined yield optimization (2). For the application with three or more responses to be maximized, an analogous economic (or value) weighting into a single response is the only requirement.

2. Multi-response optimization (maximization with response restrictions)

This includes problems which define one of the responses in a restricting sense. That is, in place of the requirement that yield and rate be maximized, yield itself be a maximum but at a specified production rate. This is a reasonable requirement since, in general, many different combinations of operating conditions will result in the same production. What is required, is to find at which of these conditions the yield is highest.

For the above two alternatives only the second requires further discussion.

Consider the original example of yield, Equation (2), and a second response for production

$$y_2 = 100 + 3x_1 + 2x_2 - x_1^2 - 2x_2^2 - 4x_1x_2 \qquad (5)$$

For this application it is necessary to determine the x_1 and x_2 levels which will result in meeting a production requirement $y_2 = 101.5$ and simultaneously maximize yield. The contour plot of y_2 is given in Figure 7, on which the contour $y_2 = 101.5$ (D) has been drawn. The problem then corresponds to superimposing the contours of y_1 over y_2 and picking out the largest y_1-value which coincides with the $y_2 = 101.5$ contour line. Obviously, when the response includes only two, or possibly three, variables this can be done readily. For applications with a larger number of variables a numerical procedure is required. Through a further interpretation of the defined ridges this pro-

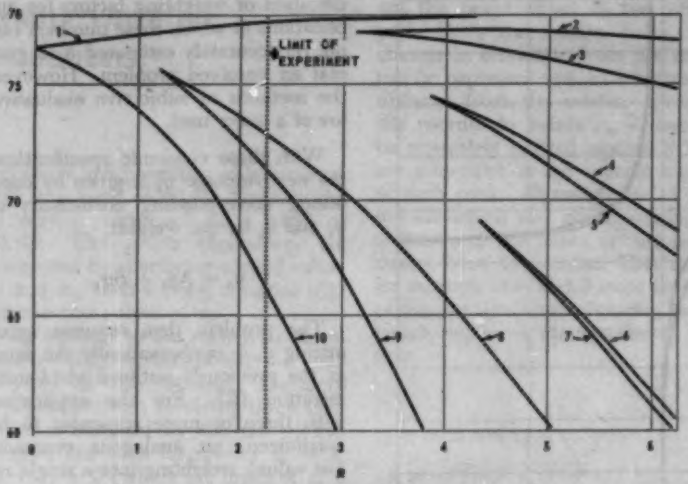

Figure 10. Minimax yield as function of radius.

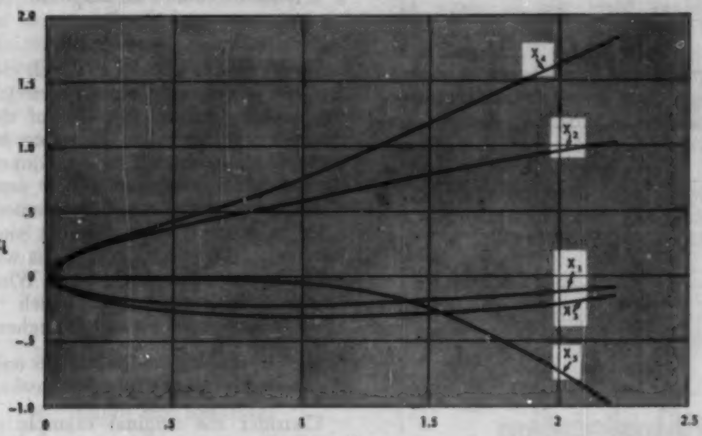

Figure 11. Five factors for optimum ridge.

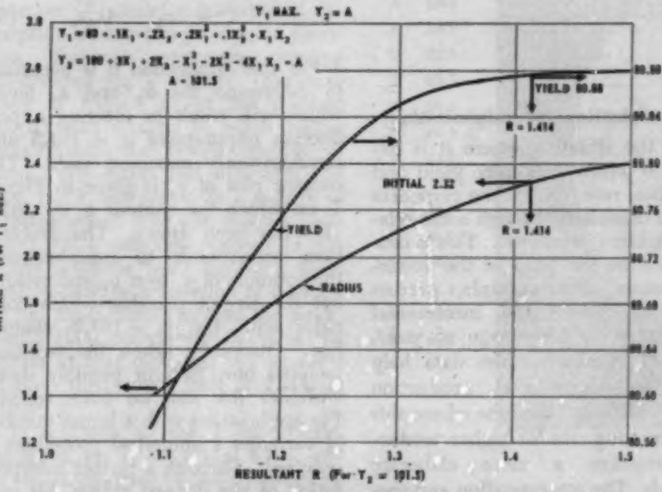

Figure 12. Multiple response problem.

Many-variable equations

continued

cedure can be used to solve the problem. As an example of the procedure, the above two-variable study is illustrated in the computations section.

Conclusions

One technique for statistically characterizing the behavior of a physical system and a numerical procedure to facilitate the interpretation and optimization of the resultant statistical models has been outlined. Through practice it has been found that this approach is quite efficient and informative for optimizing certain types of systems. However, there are many other systems which are more readily optimized by alternative techniques such as fractional factorials and steepest descent. The distinction to be drawn between these types is difficult to generalize. Rather, the selection of the appropriate procedure for a particular application should be made by the local mathematician (statistician).

Example

Derivation of ridge technique

The method for determining maximum values of a function on an n-dimensional sphere was originally developed by LaGrange (*4*). However, the extension and different interpretation of the sphere maximums for process applications justifies a re-statement and derivation of the formula. For the purpose of avoiding possible confusion caused by mathematical symbolism a three-variable function will be used in the derivation rather than the general form. The extension of the approach to the general case will be apparent.

Let

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_{11}x_1^2 + b_{22}x_2^2 + b_{33}x_3^2 + b_{12}x_1x_2 + b_{13}x_1x_3 + b_{23}x_2x_3 \quad (6)$$

with the relationship

$$x_3 = \pm\sqrt{R^2 - x_1^2 - x_2^2}$$

Substituting this identity in the response function and differentiating in respect to x_1 and x_2, and setting to zero, the following two relations are determined

$$\frac{\partial y}{\partial x_1} = 0 = \frac{\pm x_1(b_3 + b_{13}x_1 + b_{23}x_2)}{\sqrt{R^2 - x_1^2 - x_2^2}} \mp b_{13}\sqrt{R^2 - x_1^2 - x_2^2} \pm (b_1 + 2b_{11}x_1 - 2b_{33}x_1 + b_{12}x_2) \quad (7a)$$

$$\frac{\partial y}{\partial x_2} = 0 = \frac{\pm x_2(b_3 + b_{13}x_1 + b_{23}x_2)}{\sqrt{R^2 - x_1^2 - x_2^2}}$$
$$\mp b_{33}\sqrt{R^2 - x_1^2 - x_2^2}$$
$$\pm (b_2 + 2b_{22}x_2 - 2b_{33}x_2 + b_{12}x_1) \qquad (7b)$$

Back-substitution of

$x_3 = \pm\sqrt{R^2 - x_1^2 - x_2^2}$ reduces the equations to

$$x_1\left[(2b_{11} - 2b_{33}) - \frac{b_3 + b_{13}x_1 + b_{23}x_2}{x_3}\right] + b_{12}x_2 + b_{13}x_3 = -b_1 \qquad (8a)$$

$$x_2\left[(2b_{22} - 2b_{33}) - \frac{b_3 + b_{13}x_1 + b_{23}x_2}{x_3}\right] + b_{12}x_1 + b_{23}x_3 = -b_2 \qquad (8b)$$

For convenience, let

$$\lambda = \frac{b_3 + b_{13}x_1 + b_{23}x_2}{x_3} \qquad (9a)$$

then

$$[(2b_{11} - 2b_{33}) - \lambda]x_1 + b_{12}x_2 + b_{13}x_3 = -b_1 \qquad (10a)$$

$$b_{12}x_1 + [(2b_{22} - 2b_{33}) - \lambda]x_2 + b_{23}x_3 = -b_2 \qquad (10b)$$

Also, the λ relation can be rewritten as

$$b_{13}x_1 + b_{23}x_2 - \lambda x_3 = -b_3, \qquad (9b)$$

which can be used as another equation. Therefore, three simultaneous equations in three unknowns, as a function of the now arbitarary parameter λ, are thus defined. This means that for any assumed λ, the values x_1, x_2, and x_3, become fixed and correspond to the coordinates of a point (on a sphere) at which y has a maximum or minimum value. The distance of the sphere from the center is then given by the coordinates themselves

$$R = \sqrt{x_1^2 + x_2^2 + x_3^2} \qquad (11)$$

The interpretation of the resultant three equations is somewhat different than it would have been with the originally derived two relations in x_1, x_2, and R. For the original form, with a selection of R (the radius of interest) a numerical iteration technique would be required to solve for the x_1 and x_2 values—which have, in addition, multiple roots. Mathematically, this is a comparatively difficult problem requiring a substantial volume of computation especially for the large number of variable cases. As an alternative, the modified form of the equations with the λ parameter alleviates the computational difficulty. The price for this simplification is the penalty that R can no longer be specified—but is determined as a function of the selected values of λ. However, the mathematical properties of these equations are extremely convenient from a practical use standpoint.

For a particular application the values of the coefficients are specified, thus fixing the general mathematical form of the numerical equations. For simplification consider the original two-variable yield problem given by

$$y = 80 + 0.1x_1 + 0.2x_2 + 0.2x_1^2 + 0.1x_2^2 + x_1x_2 \qquad (2)$$

Using the derived form the resultant equations would be defined as

$$(2b_{11} - 2b_{22} - \lambda)x_1 + b_{12}x_2 = -b_1$$
$$(0.2 - \lambda)x_1 + x_2 = -0.1$$
$$b_{12}x_1 - \lambda x_2 = -b_2$$
$$x_1 - \lambda x_2 = -0.2$$

For convenience, a preliminary mathematical analysis of the so-called *eigenvalue* roots are made. This simply means determining the two values (in this case) of λ which makes the coefficients (of the variables) of one equation a multiple of the other equation. For example the equations,

$$3x_1 + 2x_2 = 10 \qquad (12)$$

$$6x_1 + 4x_2 = 30 \qquad (13)$$

have no solution. This can be expressed mathematically by stating that the determinant of the coefficient matrix is zero

$$\begin{vmatrix} 3 & 2 \\ 6 & 4 \end{vmatrix} = 3\times 4 - 2\times 6 = 0 \qquad (14)$$

or

$$|X| = 0. \qquad (15)$$

In essence, the λ determinant is equivalent to a polynomial of a degree corresponding to the number of equation. Thus for

$$\begin{vmatrix} (0.2 - \lambda) & 1 \\ 1 & -\lambda \end{vmatrix} = 0 \qquad (16)$$

$$-\lambda(0.2 - \lambda) - 1 = 0$$
$$\lambda^2 - 0.2\lambda - 1 = 0$$
$$(\lambda_1 - 1.105)(\lambda_2 + 0.905) = 0$$

The roots or eigenvalues are therefore

$$\lambda_1 = 1.105$$
$$\lambda_2 = -0.905$$

Either of these values substituted in the original equations makes the equations linear combinations (one a constant multiple of the other).

By-passing the mathematical interpretation, but utilizing the results, these eigenvalues are actually the key to the analysis. First, the two roots λ_1 and λ_2 enable us to classify which are the highest (maximum), lowest (minimum), and intermediate ridges. Second, as the assumed values of λ approach λ_1 or λ_2 from either side x_1 and x_2 increase without bound.

As a means of visual interpretation, Figures 8 and 9 contain plots of the various corresponding values of λ, x_1, x_2, and R for function (2). These can be obtained as follows:

1—Assume a value of λ.

2—Solve the two simultaneous equations (*4, 5*) for x_1 and x_2.

3—Compute

$$R = \sqrt{x_1^2 + x_2^2}$$

4—Compute y from Equation (2).

For example, for a selected value of

$$\lambda = 0.2$$
$$(0.2 - \lambda)x_1 + x_2 = 0.1$$

$$x_1 - \lambda x_2 = 0.2$$

$$0x_1 + x_2 = 0.1$$
$$x_2 = 0.1$$
$$x_1 - 0.2x_2 = 0.2$$
$$x_1 = 0.22$$

$$R = \sqrt{0.1^2 + 0.22^2} = 0.242$$
$$y = 80 + 0.1(0.22) + 0.2(0.1) + 0.2(0.22)^2 + 0.1(0.1)^2 + (0.1)(0.22)$$
$$= 80.07468 \cong 80.07$$

This states that at the point (0.22, 0.1) the function y has a zero derivative on the circle $R = 0.242$. Therefore, y has a maximum or minimum value at that point relative to the specified circle of reference. In addition, exactly what kind of a point this is can also be stated. This is specified by the assumed λ value relative to the eigenvalues. It can be shown (Dr. Robert Jackson of the University of Delaware derived the mathematical proof) that the largest value of y (on any specified radius R) is defined by a λ value which must be greater than the largest root λ_1 or λ_2. Similarly the absolute minimum is defined by a λ which is less than the smallest root. Also, the y values along any one ridge (bounded by the eigenvalues) can themselves only go through one maximum or minimum. That is, rise and then falloff (for larger R) only once. Further, the values of y corresponding to equal values of R (Figures 3 and 4) are ranked

Many-variable equations

continued

in increasing order by the corresponding numerical ordering of the λ's. Substantial savings in computation work and analysis are therefore obtained if only the maximum (or minimum) ridge is desired.

To further illustrate the types of response ridges defined for a larger number of variables, consider a process application involving the evaluation and optimization of five process variables on yield. For this study, the limited availability of reaction kinetic theory and data, required the use of statistical experimentation. In the initial analysis, five specific variables and yield were defined as the major considerations. A standard five factor Box-Wilson experiment with 46 tests was then carried out and the data reduced to the following relationship:

$$\begin{aligned} y = {} & 86.62 - 1.028x_1 + 0.642x_2 - \\ & 0.470x_3 + 0.584x_4 - 0.008x_5 \\ & - 1.426x_1^2 - 0.437x_2^2 - \\ & 0.281x_3^2 - 0.668x_4^2 - 0.008x_5^2 \\ & + 0.043x_1x_2 - 0.264x_1x_3 + \\ & 0.334x_1x_4 - 0.082x_1x_5 - \\ & 0.011x_2x_3 + 0.153x_2x_4 - \\ & 0.013x_2x_5 + 0.184x_3x_4 - \\ & 0.039x_3x_5 - 0.045x_4x_5 \end{aligned}$$

where x_1 = Feed rate

x_2 = Maximum pressure during cycle

x_3 = Initial pressure

x_4 = Feed composition

x_5 = Temperature

A ridge analysis, Figure 10, indicates that slightly improved yields can be obtained in the one direction which leads to the optimum point defined by R = 2.38 (limit of predictability of the function as defined by the limits of the experiment tests). Similarly the relative fanning of the maximum peak and the minimum valley indicates that almost all of the possible combinations of operating conditions would result in lower yield. This information also could be useful from a process control standpoint because of the need dictated by the relative critical nature of the variables in the direction of lower yield.

In terms of the variables themselves Figure 11 shows that for improving yield the major gains are obtained by increasing x_2 and x_4. Therefore, since this was the major consideration, x_2 and x_4 are the key variables. A similar analysis of yield fall-off showed x_1 and x_3 to be the most critical from a process control standpoint.

The computation work for this type of analysis, while tedious by desk calculator is extremely efficient on a digital computer. An analysis including eigenvalues and complete computation for all ridges for the five-variable problem requires about 20 minutes on a Univac I computer.

Two-factor multi-response optimization

To solve the general type of optimization problem stated mathematically as

$$y_1 \text{ MAX}$$
$$y_2 \leq A$$

simply requires an extension of the ridge analysis. For illustration of this method the two-variable optimization problem previously outlined will be used as an example. This included finding the x_1 and x_2 coordinates which

Maximize

$$y_1 = 80 + 0.1x_1 + 0.2x_2 + 0.2x_1^2 + 0.1x_2^2 + x_1x_2 \qquad (2)$$

for $$y_2 = 101.5 = 100 + 3x_1 + 2x_2 - x_1^2 - 2x_2^2 - 4x_1x_2 \qquad (5)$$

with $x_1^2 + x_2^2 \leq 2$.

As a preliminary step a separate ridge analysis is carried out for both functions. From the y_2 data, a check is made to confirm that y_2 = 101.5 within the bounds of the analysis (R^2 = 2). As a starting point for the optimization the coordinate points corresponding to the maximum value of y_1 (within $R^2 \leq 2$) are selected. In this case

$$x_1 = 1.03,\ x_2 = 0.97,\ y_1 = 81.4$$

This point is then used as a new center point for the y_2 function by the simple translation

$$x_1 = x'_1 + 1.03$$
$$x_2 = x'_2 + 0.97$$

and

$$\begin{aligned} y_2 = {} & 100 + 3(x'_1 + 1.03) + \\ & 2(x'_2 + 0.97) - (x'_1 + 1.03)^2 \\ & - 2(x'_2 + 0.97)^2 - 4(x'_1 + 1.03) \\ & (x'_2 + 0.97) = 98.09 - 2.94x'_1 \\ & - 4.06x'_2 - x'^2_1 - 2x'^2_2 - 4x'_1x'_2 \end{aligned}$$

From this we see that y_2 = 98.09 at the new center point (0.0) which corresponds to the point (1.03, 0.97) in the original coordinates. It should be noted that this translation of axis changes only the constant and the coefficients of the linear terms (x_1 and x_2).

With this new center point, another ridge analysis is made with the y_2 function. However, since the original eigenvalues did not depend on the linear coefficients they are still valid. Also, since we wish to get to larger values of y_2 usually only λ's greater than the largest eigenvalue need to be considered in the ridge analysis. The premise now being that we wish to find the shortest path from y_1MAX to where y_2 = 101.5. The maximum ridge tells us this exactly. The corresponding value of y_1 is then computed at this point and tabulated.

The above procedure is repeated for other coordinates from the maximum y_1 ridge until the optimum point is zeroed in. This requires at most six or seven successive analyses. A summary of the data is shown in table below.

A plot of these data are indicated in Figure 12. The successive evaluations essentially determine the values of y_1 along the path $y_2 = 101.5$ which is closest to the maximum ridge of y_1. This is traced out until y_1 starts decreasing or else the edge of the boundary (as is this case) is reached.

The final optimized y_1 value is then compared to the original ridge analysis to ascertain whether it is less than the peak value defined by the secondary ridge of y_1. If there is a secondary ridge value which is greater, the above procedure must be repeated from that point. Again however, this only requires the solution of linear equations since the original eigenvalues still hold. Similarly secondary ridges for y_2 should be sampled to guarantee the correct optimum.

Summary multiple response optimization.

R-Max y_1 (Original Coordinates)	for $y_2=101.5$ x_1	for $y_2=101.5$ x_2	Distance from y_1 Max Ridge	Original Units for $y_2=101.5$ x_1	Original Units for $y_2=101.5$ x_2	New R for $y_2=101.5$	y_1 at $y_2=101.5$
1.41	+.03	− .76	.76	1.08	.19	1.09	80.58
1.60	−.04	− .87	.87	1.13	.22	1.14	80.66
2.40	−.21	−1.48	1.50	1.54	.15	1.55	80.88
2.20	−.18	−1.31	1.33	1.43	.19	1.44	80.86

Original max. y_1 = 81.40

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Control of cleaning wastes in the food industries

Drainage from truck cleaning should be discharged into yard drains connected to the plant sewer system.

All departments of a food processing plant must be cleaned at the end of every shift. Water is the usual cleaning medium. Waste waters from cleaning operations contain residual detergents, sanitizers, food, and soil removed from processing equipment by the cleaning solutions.

This discussion will be limited to wastes from environmental sanitation activities. Washing of product, as in the vegetable, fruit, and meat industries, will not be included since this is a specialized field in each segment of the industry, and its inclusion would extend the scope of this article beyond practical limits.

The volume and character of the waste varies with the type of food processing, extent of by-product processing, size and design of the plant, and the extent to which waste-saving practices have been instituted. Flows of cleaning wastes generally range from 15 to 40% of the total flow, but in some cases may exceed the flow of processing wastes. The biological oxygen demand (BOD) and solids concentration, although normally less than those of processing wastes, will in many cases closely approach them. In some relatively dry food-processing operations, the cleaning wastes constitute the only waste flow from the plant.

Although the BOD and solids concentration of wastes from cleaning operations are usually less than those from daytime processing operations, the pollution load from these wastes is significant and can become excessive if neglected. Unfortunately, cleaning is an unglamorous after-hours operation that rarely attracts the attention of the technical staff, so cleaning waste is often relatively uncontrolled.

Cleaning compounds in waste waters occasionally contribute to operating problems. High-foaming wetting agents, sometimes used in dip tank cleaning, can cause foaming in the plant effluent if the tanks are dumped at short intervals. Severe foaming in the aerators can result if such a slug of waste is discharged into an aerobic type of treatment plant. Chemical coagulation in waste treatment will also be impaired if large quantities of detergents are used in cleaning operations. Such problems

Complicated equipment such as this margarine processing unit should be dry cleaned before flushing to reduce the discharge of fats and oils to the sewer.

can often be eliminated by reducing the amount of wetting agent in the detergent formulation.

The temperature of composite waste waters from food processing plants normally does not run above 110°F, and ordinarily ranges between 85 to 100°F during the cleaning period. Warm wastes are generally more amenable to treatment than cold wastes, but higher temperatures are harmful to some aquatic life in streams. However, this is generally no problem, since the BOD of these waste waters usually exerts a greater influence on aquatic life than does the temperature.

Some cleaning wastes are contributed during processing operations in addition to the cleaning period. For example: in the meat packing industry hooks, trolleys, gambrels, smoke sticks, molds, forms, and cutting boards are cleaned throughout the day; in the dairy industry milk cans and tank trucks are cleaned during processing periods; in most food plants, some departmental cleaning is also done during breaks and lunch periods.

Cleaning techniques and equipment

The general procedures in plant cleaning are simple. First solids are picked up, and (where necessary) floors are squeegeed to collect small particles. These waste materials are normally collected for processing as inedible by-products. The floors and equipment are then hose-rinsed with hot water (140-160°F), followed by cleaning with detergents as necessary. Detergents are applied by portable spray units or by bucket and brush. Equipment is dismantled where necessary to facilitate cleaning of all food-contacted surfaces. Metal equipment subject to corrosion is generally coated with an edible, light paraffin oil after drying. Where use of a bactericide is necessary, a chlorine or a quaternary ammonium compound is sprayed on, either after final rinsing or before use.

Cleaning compounds are generally blends of soda ash, complex phosphates, silicates, caustic soda and wetting agents. Some types of soil, such as burned-on residues and combinations of protein and fat deposits with water-hardner salts, require acid cleaners which range all the way from weak organic acids to strong mineral acids, generally in combination with wetting agents.

After disassembly, small parts may be washed by hand in a wash tank or by holding in a circulating wash tank, or may be hung on a conveyor or in bundles on a chain hoist, to be dipped into wash tanks containing detergents, circulating rinse waters or sprays, sterilizing solutions, and paraffin oil, as necessary.

Processing tanks may be cleaned by hand, although stationary and rotating sprays with either removable or fixed piping arrangements are becoming popular. In these systems detergent solution is pumped through spray nozzles in the tank and is drained back to the solution tank for continuous recirculation. Such spray systems are also used in cleaning railroad tank cars.

Piping used in conveying edible products is disassembled and washed in a pipe rack, or is cleaned in place with recirculating solutions of detergents and sanitizers by means of a pumping system designed to develop sufficient velocity to remove soil lifted from the soiled internal surfaces by the detergent solution. Closed equipment, such as heaters, coolers, and high temperature short-time pasteurizers, can also be cleaned in the same cleaned-in-place (CIP) system. The use of CIP systems in liquid food processing plants prevents accidental waste of product when piping is disassembled and permits accurate control of the volume of washing and rinsing solutions and the concentrations of cleaning materials.

In spite of efforts of engineers to design food processing equipment that can be readily disassembled for cleaning, some types of equipment, like grinders and cutters, can be disassembled only with difficulty, if at all. Various systems have been developed for cleaning such equipment. Some equipment is filled with detergent solution and operated, and in other cases detergent is sprayed on the equipment while operating.

Automation in cleaning is becoming popular in the dairy industry. Such cleaning systems consist of solution tanks, a recirculating pump, and necessary controls for metering detergents, maintaining temperatures, and timing the rinse and cleaning cycles. These systems are primarily installed to improve cleaning efficiency and reduce labor costs, and waste saving is only an incidental benefit.

Waste conservation

In spite of the many improvements in push-button cleaning, by far the greatest amount of cleaning in most food processing plants is still done by the man with the hose. Effective control of cleaning wastes requires close

follow-up of daily cleaning chores because the greatest waster of water is a careless hose operator.

A common water waster is the operator who allows the flow to continue after the cleaning job has been completed. However, there are devices which promptly stop the flow of water when the operator has finished.

Excessive water pressures can also cause unnecessary waste in the cleaning process. In many cases the water demand during cleaning periods is less than the processing demand, so water pressures may become excessive during cleanup. This problem can be controlled with a pressure reducing valve, regulated to provide adequate but not excessive pressure for any maximum demand.

In a majority of food plants, hot water for hoses is regulated by manipulating steam and cold water supply valves to individual hoses. The operator wastes water while regulating the flow for the "proper" temperature. A tempered hot water supply prevents such waste and will guarantee correct temperature for the cleaning operation. Insulating this hot water line will reduce wastage even more.

Attention to cleaning operations will also reveal opportunities to reduce discharge of solids and pollutional wastes to the sewer. Sweeping and squeegeeing to remove solids and spills can avoid unnecessary water usage. Pipe lines and tanks should be properly designed and sloped for good drainage.

Where concentrated materials are customarily flushed down the sewer, a careful evaluation of recovery possibilities should be made. Even recovery at a loss may be economically justified when the cost of treatment of this waste as sewage is calculated.

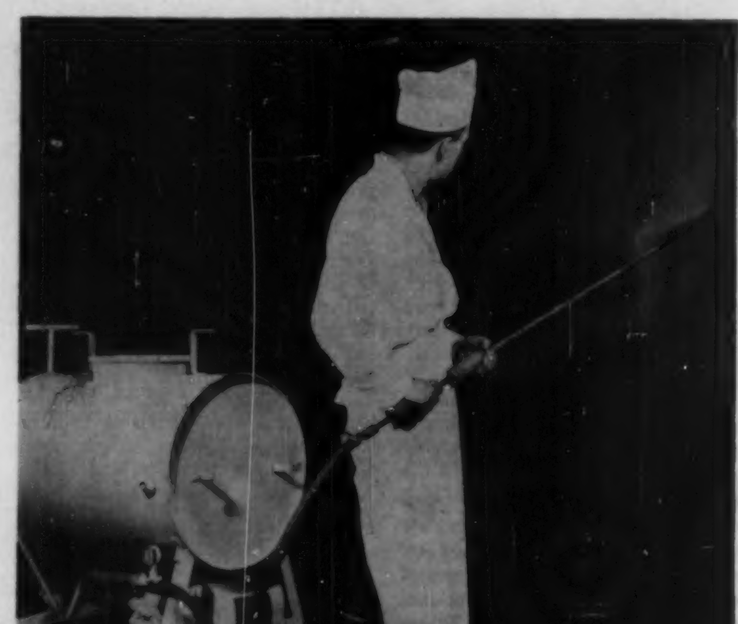
Where usable by-products must be removed, the equipment should first be cleaned dry before the regular wet cleaning. Piping can be cleaned with compressed air, and equipment such as roll and spray dryers can be dry cleaned by hand to recover product.

To insure interception of solids, floor drain grates should be bolted down. Under-floor baskets are sometimes provided under grates, but these are inconvenient and are apt to be removed by cleanup men to avoid the nuisance of cleaning them.

In spite of the trend towards the use of tank trucks in transporting milk from the farm to the dairy, most milk produced on farms today is still handled in milk cans. Cleaning of these milk cans may become a major waste problem in the dairy plant. Can-washing equipment should be arranged to provide for a drip saver and for pre-rinse of the can before washing. This drip milk is retained in a can or tank. The volumetric pre-rinse is also retained. Installation of drip savers and pre-rinse facilities on can washers generally removes from 2½ to 5 lb. of BOD/10,000 lb. of milk received.

The food industries have given relatively little attention to the advantages of re-use of clear processing waters for cleaning so-called "inedible" areas and equipment. Clear used waters can be re-used in such operations as cleaning poultry batteries, hog pens, whey tanks, waste product lines, and piping used for conveying inedible product. Such waters can also be re-used as spray water on vibrating and rotary sewage screens.

Cleaning wastes should be discharged through any treatment facilities installed at the processing plant in connection with regular processing operations. Thus, cleaning wastes at canneries where rotary or vibrating screens are provided should be discharged through these screens, and wastes at packing plants and milk processing plants should be discharged through whatever grease retaining and solids recovery facilities are provided for the daytime wastes. This seems self-evident, but is sometimes overlooked.



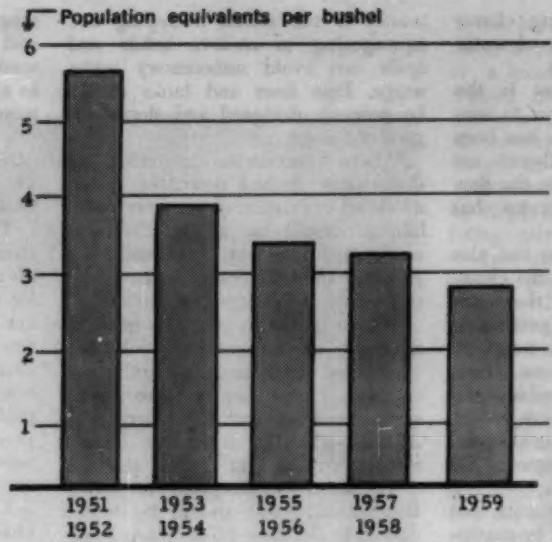
Drainage from cleaning smoke houses unavoidably carries some greases to the sewer where they are recovered in properly designed grease-recovery basins.

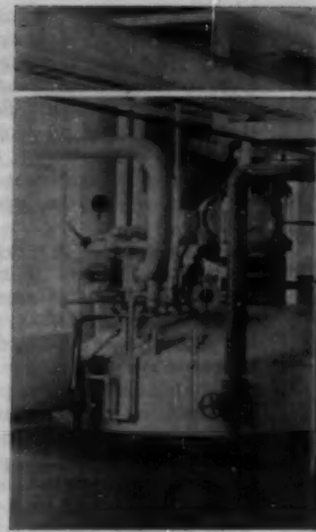
Control methods

Composite sampling and measurement of the waste flow are essential elements in any waste control program. Before improvements of any kind are made, the entire waste flow from cleaning operations should be sampled and measured in proportion to flow. The same procedure should be followed after all improvements are installed and operating to determine the over-all benefits of the waste control program. The benefits of individual waste saving measures can be evaluated separately in the same manner.

Since some of the improvements necessarily involve training of personnel in conservation practices, it is important that regular inspections be made to insure compliance with the waste conservation measures. The status of the program can be evaluated from time to time by flow measurement and sampling surveys. These surveys are no different from those conducted for processing wastes, but since surveillance of cleaning operations by technical personnel is generally limited, such periodic studies are sometimes the only yardsticks by which the control of cleaning wastes can be measured. #

Chart shows the reduction of pollution load by in-plant methods at Hiram Walker's Peoria, Ill., grain distillery. (Far right) Stillage with added nutrients is fermented to riboflavin feed supplements.





By-product recovery

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Pollution control measure

in the fermentation industry

The primary responsibility for industrial waste control lies with industry managements.

For the fermentation industry the *entire plant* approach to waste control engineering has proven profitable. Development of by-products involves marketing, engineering, and other research. Waste data in terms of population equivalents per unit of primary raw material or product have been found to be important bases for management's assay of current operations and prospective in-plant recovery projects.

The distilling industry recovers 90% of its fermentation residues as dried feeds; some is fed wet. Dried feed sales approximate $18,000,000 annually. This in-plant recovery reduces the potential pollution load from 50 to 55 down to 2 to 4 population equivalents per bushel. The brewing industry has a similar program.

Much of the research on in-plant recovery for the wine industry remains to be applied. The antibiotic industry is gradually working out in-plant recovery and waste disposal measures.

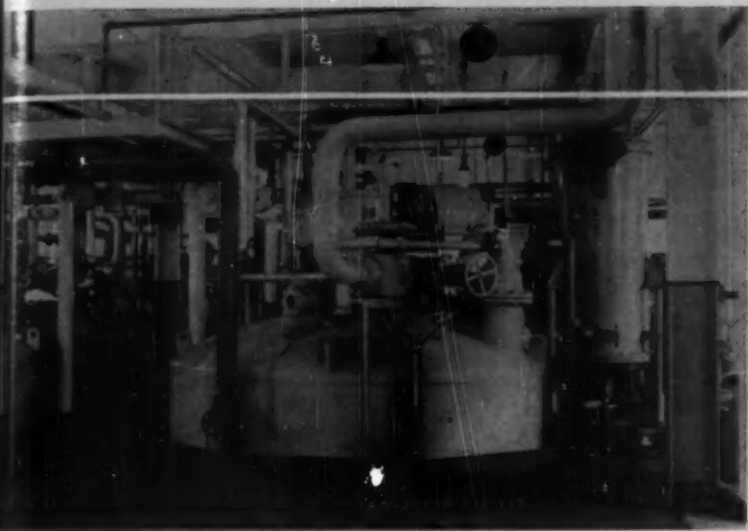
The broad *entire plant* approach to waste control has proved profitable for much of the fermentation industry. After production of a primary product, be it an alcoholic beverage or an antibiotic, a considerable amount of organic material remains. Evaporation and drying of residues and secondary fermentations (so-called in-plant processes) have resulted in the development of a series of profitable by-products. With many of these products, production research alone did not suffice. It was necessary to do considerable product and customer research and promotion to establish markets for these new products.

Depending on the efficiency of in-plant recovery, and the character and down-stream use of the receiving stream, some further reduction of the waste may be necessary before final discharge. In this connection, the waste treatment plant must be regarded as only one unit in a series of processes comprising the fermentation and recovery plant.

Waste-To-Product ratio

The terms percent-of-waste-treated and percent-of-BOD-reduction are common expressions to describe treatment plant efficiencies. However, by using the *entire plant* approach to waste control, terms which reveal yields and plant efficiency, such as effluent-pounds - of - BOD - per - unit-of-incoming-raw-material, population-equivalents - per - unit - of - primary-product - processed - or - produced, or percent-recovered, have become familiar chemical engineering language. Data in these terms, defining yields of all products, afford a presentation pattern which management personnel understand, and against which they can evaluate and justify in-plant waste recovery expenditures. This terminology of expressing wastes-per-processed-unit is also applicable to intra-plant studies of waste streams from individual unit processes, and can be used in waste balance calculation for the entire plant.

The degree of dilution of an effluent is often within the company's choice of operating methods. Once-through cooling methods, using an abundant source of water, may afford the most economical production method in certain cases, and, in fact, may have been the primary consideration in the choice of the plant's location. High-volume use of a water resource does not conflict with good pollution con-



Periodically, depending on in-plant changes, a process-by-process survey (Table 1) is made to define the sources of wastes in terms of waste-per-bushel-of-grain-mashed. With these data at hand, production personnel and management assay the waste ratios and take any action needed. An annual sewer survey is used to check total wastes against the less frequent process-by-process in-plant surveys. Hiram Walker and others (22, 23, 24) have found this a workable and effective program.

In-plant by-product recoveries

In-plant by-product recovery data for the grain distilling and brewing industries, as given in Tables 2 and 3, illustrate some of the industries' accomplishments in recovering and marketing by-products. Across-the-industry data may suggest further economically sound by-product recovery processes for certain segments of the fermentation industry. These summaries show by-products which are being marketed, and the amount of unused waste which remains as a challenge for further work. The many products that research workers have reported as obtainable from fermentation residues, but which have not been brought to market, are, of course, important to further development of in-plant recovery procedures. The data show the amount of animal feed by-product potentially available for recovery, the amount being recovered, and the sales dollar value of the feed products. Data in these terms for the distilling and brewing industries are available from voluntary reports by the industries to the U.S. Department of Agriculture. Some small production may not be reported.

The grain distilling industry

Waste recovery data for the grain distilling industry are summarized in Table 2.

Using the entire plant approach to reporting and controlling wastes, grain distilleries operating complete stillage recovery departments reduce potential wastes from a population-equivalent-per-bushel-of 50 to 55 down to 2 to 4. For the industry as a whole, approximately 90% of avail-

continued

Through the application of chemical engineering methods, the fermentation industries have accomplished waste control by in-plant recoveries which now show a profit.

trol practice unless the final waste must be treated.

Hiram Walker experience

In the Hiram Walker grain distillery in Peoria, Illinois, an eleven-year program of intraplant waste surveys has been coordinated with annual final effluent surveys to permit definition of waste sources within the plant, and assay of the waste discharged by each individual unit process. Survey data from the individual units and the final effluent to the Illinois River are converted to the following common terms: pounds-BOD-per-thousand-bushels-of-grain-mashed; population-equivalents-per-thousand-bushels-of-grain-mashed; and pounds-of-waste-solids-per-thousand-bushels-of-grain. A waste balance table is prepared to relate the amount of waste coming from each unit to the total final effluent. Findings have been reported by Boruff (5) and Boruff and Blaine (6). To illustrate the advantages of this approach in obtaining practical improvements of in-plant recovery processes, Table 1 has been excerpted from the plant's waste balance table of 1953, and annotated to illustrate three additional operating changes made shortly thereafter. But only the "Population Equivalent Per Bushel Mashed" and the "Percent of Plant's Total Population Equivalents" are presented for this illustration. From the itemized source of waste data given in Table 1, it will be noted that two waste entries, that is, "Fume Chamber Scrubber Trap for Vapors from Drum Dryers" and "Dust Collector for Dried Grains Dryers," accounted for 31.4% of the total plant waste load to the Illinois River in 1953. A vapor-dust collector wash with solids recovery system, to eliminate these two waste sources, was designed. Estimates of capital cost compared to probable added by-product feed recovery were presented to management. Authorization and installation followed. This 31.4% of total waste load, as of 1953, was eliminated in 1954. Figures show the unit is gradually paying for itself through additional feed recovery. Also, about 90% of the "Fusel Oil Wash Water" waste has been eliminated by small changes in still design and operations.

Accomplishing successful in-plant recovery of wastes demands a constant vigil to control and improve recovery operations. At Hiram Walker, the primary responsibility lies with the foreman of each unit process.

By-product recovery

continued

able by-product feedstuffs go to market as dried feeds. In so doing, an average of about 285,000 tons of animal feed concentrate enter the market each year at a total value of slightly over $18,000,000. This is a substantial contribution to the overall feed and food economy of the nation. This in-plant recovery of feed from stillage is accomplished at a net profit to the industry.

Some fractions removed in refining spirit distillates, consisting mostly of amyl alcohols, are marketed as raw stock for solvents. In point of value and volume the amount is very small, but the chemical nature of these fractions classes them as the most potent remaining waste of a distillery.

Research toward development and marketing of more distillery by-products continues. Of special interest is current work on stillage residues as major media for secondary fermentations to produce specialty feeds of high vitamin or other growth factor content and consequently high commerical value. Hiram Walker has marketed riboflavin feed supplements since 1949. These can be produced by a fermentation of supplemented grain stillage.

Table 1. Itemized sources of industrial waste from modern grain distillery practicing complete stillage recovery showing improvement resulting from elimination of three waste sources

Source	1953 Population Equivalents Per 1,000 Bushels Mashed	Percent of Plant's Total Population Equivalents in 1953
Cooking and Fermenting		
Pressure Cooker Blowdown	22.4	0.7
Cooker Blow Vent Stack Drippings	0.6	0.02
Cooker Vacuum Aspirator Trap	18.8	0.6
Flash Cooler	222.3	7.4
Flash Cooler Cleanup	31.2	1.0
Fermentor Cleanup	70.0	2.3
Yeast Tub Cleanup	5.3	0.2
Total, Cooking and Fermenting	370.6	12.2
Distilling		
High Wines Water	38.8	1.3
Fusel Oil Wash Water	*13.0	0.4
Slop Tester Drain	3.5	0.1
Total, Distilling	55.3	1.8
Feed Recovery Plant		
Hot Well from Triple Evaporators	1,328.2	44.1
Hot Well from Finishing Pan Condensers	187.6	6.2
Fume Chamber Scrubber Trap for Vapors from Drum Dryers	**342.4	11.4
Dust Collector for Dried Grains Dryers	**602.9	20.0
Scrubber Trap for Cyclone on Dried Grains Cooling System	12.3	0.4
Scrubber Trap for Dried Solubles Airveyor Cyclone	1.2	0.04
Equipment Cleanup	35.3	1.2
Total, Feed Recovery Plant	2,509.9	83.3
Powerhouse (powdered coal, wet ash, and fly ash recovery), Total	72.9	2.4
Grand Total in 1953	3,008.7	99.7

* *This waste load has been reduced about 90%; see text.*

** *This waste load recovered to feeds in 1954; see text.*

Fermentation of molasses

Most of the industrial alcohol, butanol, and acetone marketed in U.S. is produced synthetically. Periodically, however, when the ratio of the price of molasses to that of high-proof alcohol is low, some is produced by fermentation. The main producers have developed molasses, dried fermentation solubles, and other feed by-products from their stillage, thereby materially increasing their in-plant recoveries and reducing their effluent waste load.

The brewing industry

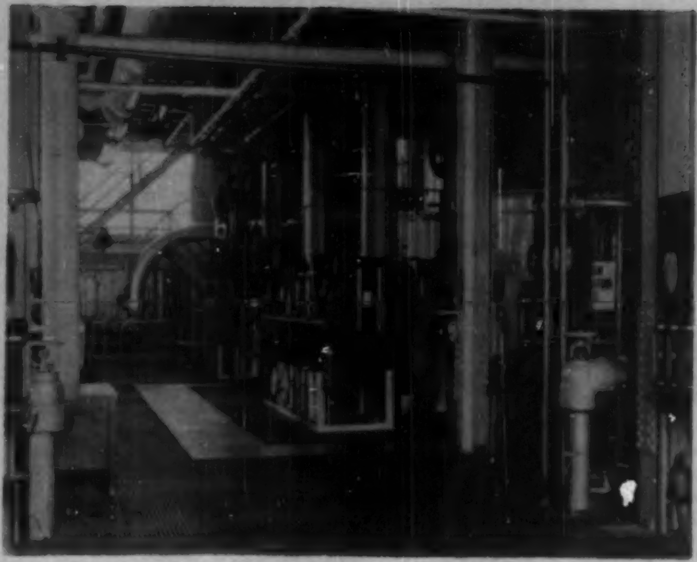
Brewing industry data are summarized in Table 3. The 31-gallon barrel of beer is the common production unit of the brewing industry. Variation in raw material presents a problem in summarizing waste and by-product recovery. Certain adjuncts result in a larger residue available for production of brewers dried grains than others.

Progress in recovery efficiency for breweries is indicated in that Mohl-

The role of the chemical engineer in waste control

The chemical engineer enters the waste control picture as the agent of management. His training (*1*) qualifies him as the natural liaison man between production departments, management, and the regulatory agencies representing community interests. His training and daily duties cover chemical plant design, operating efficiencies, and process development. The terms *material balance, heat balance, process cost, yield, waste rate,* are basics in this profession. His day-to-day operation, in one function or another, is to inform management of plant efficiencies in terms to which management has become accustomed. Here is the role the chemical engineer is playing, in accomplishing waste control in the fermentation industry through in-plant recovery of marketable by-products and how some of the waste reductions are made by policing and improving the efficiencies of various fermentation and recovery processes.

The chemical engineer's role in waste control assignments, and management's responsibility for progress in this field have been stated by others. Kraus (*2*) considers control of process losses equivalent in importance to product quality control and cautions industry to consider waste control as much a part of process design as the power source or the water source. Shipman (*3*) points out that if management is to meet its responsibility in waste control mat-



Stillage for by-products is drawn from these stills with the distilled beverages.

man in 1939 (*11*) and the U. S. Public Health Service in 1943 (*7*) reported the average waste rate for breweries practicing recovery as being 19 population-equivalents-per-barrel, as against 12.4 reported by Hale (*10*) in 1953.

Several government and industry sources of information were consulted to estimate the actual recovery and marketing of brewers by-products (*8, 9, 12, 13, 14, 15*). In 1957, a total of 235,000 tons of brewers dried grains was marketed (*8, 9*), or 42% of the estimated potential. At $40 to $50 per ton, this represented a sales value of about $10.5 million. In addition, it is estimated that 15% of the available by-product grains was marketed in mixtures with other protein concentrates and 10% was marketed in feedstuffs by adjunct millers. The unit value of these products is similar to brewers dried grains. This leaves a considerable portion, estimated at 20% of available by-product grains for wet feeding. This outlet is used to a greater extent in the brewing industry than in the distilling industry because many small breweries are suitably located to dispose of their pressed wastes without drying.

Very little hops residue goes to market. Apparently a feed market cannot be developed due to its bitter flavor, although up to 6% has been mixed in brewers feeds. Hops residue has fertilizer value and some brewers press and burn the residue. Probably 10% is marketed at low value.

Brewers dried yeast is a valuable product going to market as human food supplements, and as feed ingredients for higher grade animal feeds and pet foods. Some is further processed to yeast nucleotides and other bio-products (*16*). The larger breweries reclaim nearly 100% of the available brewers yeast. Some smaller breweries send yeast concentrates to larger plants for drying. Reclamation of 70% of available yeast, at a market value of $3,250,000, is estimated. The portions elaborated to U.S.P. grade and other bio-products represent higher value.

The brewing industry recovers a high percentage of available by-products and, thereby, attains a low waste-to-primary product ratio. Challenges for further research lie in the more complete recovery of dried yeast, brewers grains in dry form, and uses for spent hops.

The wine and brandy industry

The wine industry presents some of the most difficult waste control problems to be found in any branch of the fermentation industry. The seasonal nature of the industry causes much of the year's waste to be produced in three months' time. Also, the processes which comprise the industry must be adjusted from year to year to match the types of grapes available.

Except for tartrates, no stable market exists for U. S. winery by-products. As a result of the war, Matchett (*17*)

continued

ters, the industry's technical staff must advise management by way of engineering data and must avoid slanting reports to placate management while maintaining a *status quo*. Johnson (*4*) cautions the chemical engineer to look beyond intensive study of the design and operation of unit apparatus, to apply chemical engineering to an integration of the entire plant, and to consider the economics of operation of the entire corporate enterprise.

Table 2. By-product recovery by the grain distilling industry.

Primary Product	Production, Year Ending May 31, 1958 56-pound Bushels	Estimated Waste Potential Pop. Equiv./Bu.	Residual Waste, Current Complete By-Product Recovery Pop. Equiv./Bu.
Ethyl Alcohol from Grain; Beverage Spirits and Industrial Alcohol	37,377,000	50 to 55	2.0 to 4.0

	Potential Available By-Products		By-Products Marketed, Year Ending May 31, 1958	
By-Products	Pounds per Bushel	Tons, Year Ending May 31, 1958	Tons	Percent of Available
Distillers Dried Grains				
Distillers Dried Grains with Solubles	17	317,705	284,900	90
Distillers Dried Solubles			(Value—$18,250,000)	
Fuel Oil .... (Mainly amyl alcohols)	0 to 0.07	......	Data not available	
Carbon Dioxide	17	317,705	Data not available; some distillers recover.	

continued

reported in 1944 that tartrates were being recovered from pomace and stillage as well as the lees and argols accumulating from U. S. wine manufacture. At that time, this production accounted for a substantial portion of the 15,000,000 pounds of tartrate used annually. It was estimated the U. S. wine industry could produce 10,000,000 pounds of tartrates annually from pomace and stillage alone. Today's wine production has increased to one and one-half times the 1944 annual rate. Vaughn and Marsh (*18*) point out that the recovery of tartrates would be a practical first step toward reducing the BOD of brandy stillage. They have shown brandy stillage BOD is reduced 50% as the stillage passes through the tartrate recovery process.

In processing around 1.25 million tons of grapes per year, it is estimated that there is produced about 130,000 tons wet weight of pomace and other wastes. According to a private communication from Vaughn (*19*), current by-product recoveries are so low that considerable circularizing of the industry would be necessary to obtain data on the small amount of recovery and utilization that is accomplished, aside from argol tartrates. There is a great in-plant recovery potential in wine wastes. Although at the present time very little use is made of U. S. wine residues, much research has been done. With the present trend to modernization and to consolidation into larger units, collection, reclamation and developing uses for these wastes should be encouraged. If in-plant recovery of residues is not advanced, this industry will face increasingly difficult problems of treating its final wastes.

The antibiotic industry

The antibiotic industry is the youngest member of the fermentation family and is gradually accomplishing in-plant recoveries. The fermentation and the substrate variances necessary to produce the wide range of antibiotic products present substantial problems to the engineers working on in-plant recovery. The fermentations are aerobic, thereby presenting danger of foamover shock loads for the waste recovery plant. Each antibiotic presents its own pattern of recovery and waste problems. The industry has relied heavily on waste treatment as a means of pollution control. Methods for incineration of wastes have been developed to supplement conventional treatment plant methods (*20*). For these reasons, the current literature describes antibiotic wastes in terms of BOD potency, but there are little data of the type presented for the distilling and brewing industries to show waste recovery efficiencies.

The data in Table 4, reported by one antibiotic manufacturer, indicate that waste loads can be greatly reduced by in-plant recovery. Because antibiotic potencies and yields are characteristically low, the ratio of waste to primary product is high compared with the older fermentations.

The organic composition of antibiotic fermentation residues and the synthesis of vitamins during antibiotic fermentation suggest recovery and utilization of these residues in feedstuffs. However, use of solvents, filter aids, and chemical treatment in the separation and purification of antibiotics, the toxicity of some fractions, and the commingling of wastes, complicate recovery of feed products. One producer estimates that 65% of antibiotic residues are recovered. Even in view of the problems involved, the size the antibiotic industry has attained warrants continuation of the chemical engineering work on in-plant recovery. Total antibiotic production in the United States, for human and veterinary medicine only, for the year ending June, 1958, has been estimated at greater than two and a quarter million pounds, valued at over $300,000 (*21*).

Table 3. By-products recovery by the brewing industry.

Primary Product	Production, Calendar Year 1957 31-Gallon Barrels	Residual Waste with Current Complete By-Product Recovery Pop. Equiv./Bbl.
Beer	80,450,716	12.4

Calculated Available By-Products			By-Products Marketed		
By-Product	Lb./Bbl.	Potential Tons, 1957		Tons	Estimated % of Available
			As Brewers Dried Grains	235,000	42
			(Sales value about $10,500,000)		
Brewers Grains	12.5	559,067	In Mixed Feeds	84,000	15
			Retained by Adjunct Processors	56,000	10
			As Wet Pressed Brewers Grains	112,000	20
			Total	487,000	87
Malt Sprouts	0.9	40,253		38,240	95
Yeast	0.5	22,362		15,653	70
Spent Hops	0.3	13,418		1,342	10

Table 4. Waste recovery in an antibiotic plant.

Product		Waste Rate Without Recovery	Waste Rate With Recovery
Penicillin	Pounds BOD/Pound Product	9.1	1.4
Streptomycin	Pounds BOD/Pound Product	7.9	0.5
Vitamin B_{12}	Pounds BOD/Gram Product	4.9	1.5

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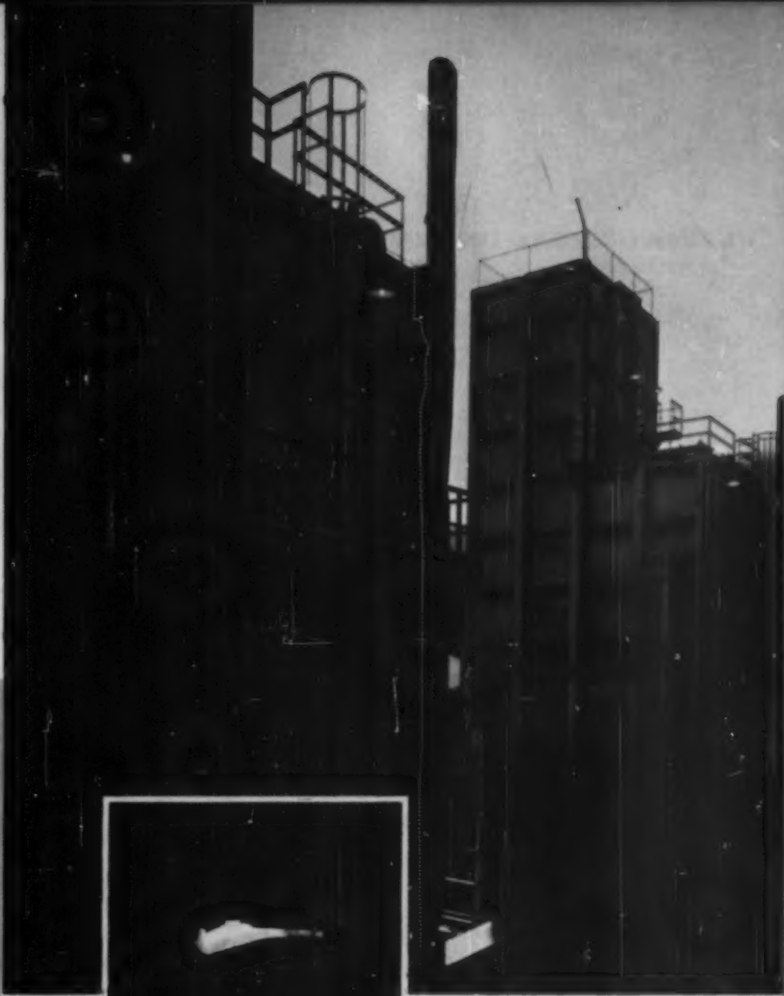

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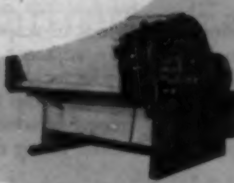

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CEP

COMPUTER PROGRAM abstracts

The Machine Computation Committee of the A.I.Ch.E. is interested in receiving program abstracts. Once again the Committee wishes to emphasize the three rules for participation in the interchange program:

1) Abstracts submitted for publication must follow the form published in *CEP* (January, 1959) and in the *Guide*.

2) Abstracts must be sent to the Machine Computation Committee c/o A.I.Ch.E.

3) All questions relating to published abstracts must be sent to the Committee c/o A.I.Ch.E. in New York.

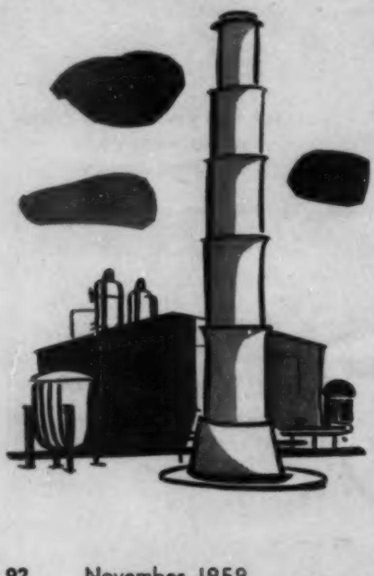
Self Supporting Steel Stack (009)

Arthur G. McKee & Company
Oil Engineering Department
Cleveland 1, Ohio

Description: The program will design a self supporting cantilever stack (no guy wires) having a given diameter and height. The shell thickness necessary to meet specifications is computed at two foot intervals from the top to base ring and wherever necessary the plate thickness is increased and punched out.

Shears and moment are given at the base and shipping and operating weights are computed. The skirt, which may be tapered or straight, and the base ring are also designed.

The crticial wind velocity at which vibration may occur is computed by empirical formulae. These velocities are compared to the range of prevailing wind velocity and punched out so that the engineer may make design changes if necessary.



Computer: Basic 650 with Alphabetic Attachment 2000 Word Storage.
Program language: Bell L_1 Interpretive Routine.
Running time: Approx. 10 minutes.
Availability: A program manual can be made available for publication should sufficient interest develop.

Growth Curves (029)

L. H. Krone
Applied Mathematics Section
Monsanto Chemical Company
St. Louis 66, Missouri

Description: The program will fit a variety of growth curves, using the method of least squares to obtain estimates of the regression coefficients. Extrapolations are made for an arbitrary number of future years and confidence limits are obtained for the extrapolations.

The curves fitted by the program are:

Linear	$y = A + Bx$
Quadratic	$y = A + Bx + Cx^2$
Semi-log	$\log y = A + Bx$
Quadratic in logarithms	$\log y = A + Bx + Cx^2$
Logistic	$y = KA^{Bx}$
Gompertz	$y = K/(1 + \exp(A + Bx))$

The equation or equations desired in a particular case are indicated on a control card which also contains convergence criteria or iteration limit.
Computer: IBM 704, 8k core, 1 tape (optional-output).

Program language: Fortran II.

Running time: This is a function of the number of data points and the amount of extrapolation requested. A typical case of 20 data points and a 10-year extrapolation would run about a minute, including on-line output.

Availability: A program manual can be made available for publication should sufficient interest develop.

Calculation of Tension in Span Adjacent to Broken Conductor (026)

F. E. Swain and T. M. Austin, Electronic Data Processing Section, Office of Assistant Commissioner and Chief Engineer, Bureau of Reclamation, U. S. Department of the Interior, Denver Federal Center, Denver, Colorado.

Description: The program computes the tension in a high voltage transmission line conductor, supported on strings of suspension insulators, in the span adjacent to a span in which the conductor is broken. The desired tension is the intersection of 2 curves, 1 curve of conductor tension versus insulator string deflection, and 1 of con-

ductor tension versus change in span length. For both curves, points must be compute for assumed values of tension.
Computer. Basic IBM 650 with 533 card input-output unit.
Program language. Program prepared with SOAP routine. Program uses SIR.
Running Time. Three to four minutes per problem.
Comments. Input and output are in fixed point. Calculations made in floating point.
Availability. A program manual can be made available for publication should sufficient interest develop.

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All this began seven years ago when Fluor engineers built a scale model and rigged miniature hoists to solve a difficult erection problem. Success of this trial led to experiments with the use of models as a basic design tool. Cost studies showed substantial savings in drafting man-hours (net savings, above modelmaking costs.)

Today, models are to be found in most of Fluor's drafting rooms, and nearly all Fluor-built plants are designed with the aid of this tool. Beyond the dollar savings there are many less tangible benefits. Sizable groups can confer over a model, reach quick agreement on layouts, approve or revise many details at a single session.

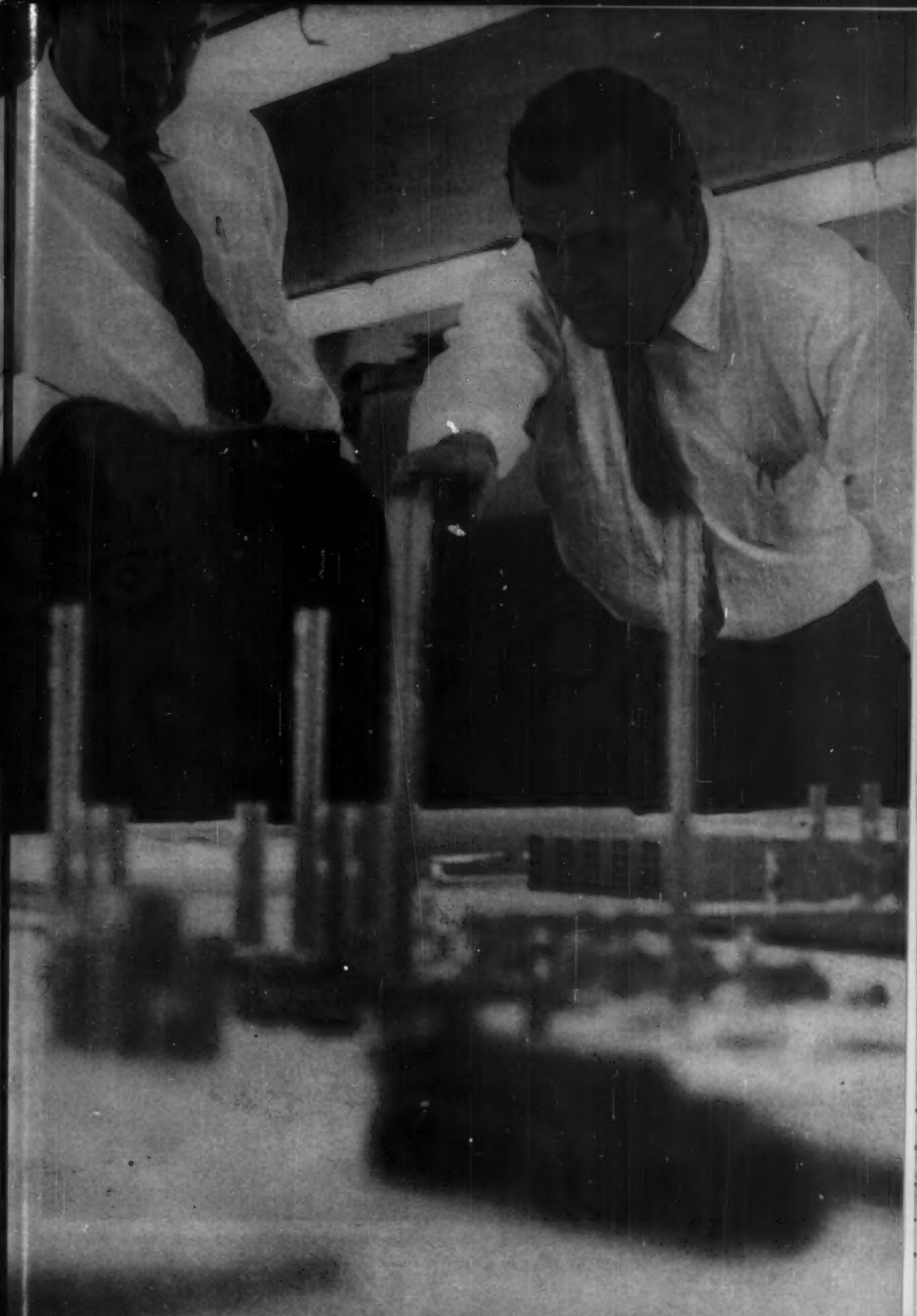
Piping runs are shorter and more direct, valves and instruments are more accessible when designers lay them out on a model (a Fluor comparison study of a refinery design showed a \$50,000 saving in pipe, fittings and fabrication by use of a model vs. conventional layout drawings.)

Costly revisions are minimized when many specialists can study a complete plant in miniature before construction begins. In the field, models serve as a reference for construction crews and a guide for operator training.

Unless scale models are properly used—as a basic, integrated design tool—most of these advantages are lost. The development and refinement by Fluor of design techniques using scale models has been a creative contribution to the engineering and construction industry.

For more information on the use of scale models in design and construction, write to Dept. 59, The Fluor Corporation, Ltd., 2500 South Atlantic Boulevard, Los Angeles 22, California.

For more information, turn to Data Service card, circle No. 67



meeting preview

Atlanta – focus for engineers

G. A. Howland
Tennessee Corp.
Atlanta, Ga.

Atlanta ranks right long with New Orleans and Miami as the South's most cosmopolitan centers. It is also known as the convention city of the South, so A.I.Ch.E. members and friends who attend the National Meeting, February 21-24, will be right at home. Georgia's capital, which still retains many of the prim trappings of an earlier age, has also become very 'big city'. Visitors will find her a charming hostess with gracious old South manners and modern new South ambitions.

The natural crossroads of the southeast, the city was born as the southern terminus of a state-owned railroad. It is still an important rail center. Indian trails hundreds of miles long converged here from half a dozen directions, and on the Chattahoochee River, a few miles from the center of Atlanta, was the big Indian town of Standing Peachtree. From this, Atlanta's nationally famous Peachtree Street gets its name.

Rich in Civil War history, Atlanta was the spot on which a crucial battle of the Civil War was fought. When Sherman captured the city and started his famous march to the sea, which ended in Savannah, the end of the Confederacy was also in sight.

Georgia's State Capitol stands on the site of Union Army's camping ground during Battle of Atlanta.

Post war boom

Long a business hub, the distribution and warehousing center for 23 million people in the southeast, Atlanta also has the world's largest farm market. The $10 million State Farmers' Market is a clearing house for foodstuffs for the tables of Atlanta's million population, from farms in Georgia and the rest of the South.

Before World War II, Atlanta was economically two parts commerce and one part industry. Since the war it has come to rank as one of the top ten industrial areas in the United States. There are almost 89,000 production workers and 91,000 in retail and wholesale trade. Over 1000 new plants have been built since the war, and the trend continues. A total of 1700 firms produce half a billion dollars worth of goods each year, making Atlanta one of the leading cities in the nation in advancing manufacturing.

Textile manufacturing, while important, never dominated the town as it did in other southern cities. The Exposition Cotton Mills, however, are a stable element in Atlanta's economic picture, turning out 12 million miles of yarn a month. Atlantic Steel makes cooperage hoops and cotton ties, items produced in only

continued on page 98

This home in the northside residential area is typical of the many beautiful homes and gardens for which Atlanta is famed.

For more information, turn to Data Service card, circle No. 165

Atlanta

from page 96

Stone Mountain, site of the proposed Confederate memorial, is 16 miles from Atlanta.

two other mills in the country, both in Birmingham.

One of the first cities in the south to recognize the need for planned industrial districts, Atlanta opened Peachtree Industrial Boulevard in 1945. The 1000 acres hold more than 40 factories and warehouses, including Eastman Kodak's film processing center and Buick-Oldsmobile-Pontiac assembly plant.

Lockheed Aircraft is the largest single private employer in the state. Standing on the site of one of those cotton patches that were once the backbone of Georgia economy, Lockheed last year paid out $92 million in wages. Research is also important at the company, with considerable work in nuclear radiation going on.

Area chemical industry

At present there are 44 plants in the area that are directly concerned with chemicals. These vary from the production of cleansers, insecticides, and paints, to plant food products. Petroleum products and ceramics are also part of the city's industry.

Coca-cola is an Atlanta-born beverage. Since the first coke was served at a soda fountain in the city in 1886, over one billion gallons have been manufactured. It is now on sale in 105 countries throughout the world.

Confederate memorials

Places of interest to be seen in the territory include the very beautiful Stone Mountain, the largest single body of exposed granite in the world, which stands several miles around the base and almost a thousand feet from summit to base. The Stone Mountain Confederate Memorial is being carved across this. Another Civil War me-

continued on page 100

13

CHOICES

for improved solids deliquefication

4 sizes of CONICAL SCREEN CENTRIFUGE

The Sharples Continuous Dehydrator is especially applicable for high concentrations of medium-to-coarse crystalline solids and fibrous pulps.

By changing the size of the openings in the perforate plate and by changing the rotational speed, varying degrees of liquid clarity and/or solids dryness can be achieved as desired. Available in four sizes, with solids handling capacity ranging from a few hundred lbs./hr. to 50 tons or more/hr. —e.g., on synthetic ammonium sulphate the Model 510 will dewater 50 tons/hr. or more to 1% or less residual moisture.

Write for Data Sheet on the Sharples Continuous Dehydrator.

3 sizes of AUTOMATIC PERFORATE BASKET CENTRIFUGE

The Sharples Super-D-Hydrator has an excellent performance record on materials with low drain rates, where product purity is of critical importance. By applying high centrifugal force (to 1250 x g), a unit load of crystals can be handled very rapidly; with the thin crystal layer, there is little filtration resistance, and crystals quickly give up mother liquor. Designed for multiple rinsing for super purity such as is demanded by the polyolefins. Capacities range from a few hundred lbs./hr. to 25 tons/hr., depending on characteristics of slurry. Available for pressure operation. Write for Bulletin 1286.

6 sizes of SOLID BOWL CONTINUOUS CENTRIFUGE

The Sharples Super-D-Canter is a high speed clarifier or classifier, applicable to an extremely wide range of both amorphous and crystalline solids ranging from relatively large size particles down to those a few microns in size.

Solids handling capacity ranges from as little as a few lbs./hr. up to 10-15 tons/hr. and liquid handling capacity ranges from a few gal./hr. to several hundred gal./min.

For example—in the classification of kaolin clay slip a P-7000 Super-D-Canter delivers 16 to 18 tons/hr. of classified product in the liquid discharge (80%-90% 2 microns).

Models are available for operation at pressures to 150 psi. Write for Bulletin 1254.

Whether You are Deliquefying a Super-Pure Hydrocarbon, Dehydrating Ammonium Sulphate, Dewatering Corn Fibre . . . Producing Polyolefins, Removing Suspended Solids to Clarify a Liquid . . . or Any of Hundreds of Similar Operations . . . Sharples has the type and size of modern centrifuge to do the job efficiently at low cost. That's why it will pay you to get in touch with the company that has them all, and can recommend the one best suited to your needs . . .

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For more information, turn to Data Service card, circle No. 77

Atlanta

from page 98

morial, the Cyclorama, is a panoramic painting of the Battle of Atlanta. The city-owned painting, completed in 1887, is valued at more than a million dollars. It is 50 feet high, 400 feet in circumference, and weighs 18,000 pounds.

The Museum of Agricultural and Mineral Resources of the State, in the State Capitol Building, is seen by many visitors each year.

Atlanta is famous for its golf courses, on which such greats as Bobby Jones, Alexa Stirling, Watts Gunn, and Charlie Yates have trained. Then, of course, there are the rambling wrecks from Georgia Tech, the football team that needs no introduction.

Georgia Institute of Technology (Georgia Tech), the south's largest engineering university, is just four blocks from the well known Peachtree Street. Its 5700 students are drawn from over 40 states and 35 foreign countries. Fifteen degree granting schools, including a thriving Chem-Engineering Department, and a research center are part of the state-supported institution. Just completed in a $15 million building program is the $600,000 radio-isotopes and bioengineering lab modeled after the Oak Ridge Institute. In the design stage is a $4,300,000 nuclear reactor.

Combined enrollments at the city's twelve degree granting institutions, six white, six Negro, is 25,000. As a matter of fact, the capital city had three institutions of higher learning before it had a public school system. Emory University, one of the state's leading medical schools, graduated over 70 doctors last year. Oglethorpe University is in the midst of an expansion program.

A final word, to the gourmet: Atlanta's cosmopolitan atmosphere is nowhere so evident as in the restaurant fare that is offered. Traditional southern cooking, prime ribs of beef, polynesian food are all available. Especially for southern cooking is Davison Paxon Terrace Tea Room. Hart's Peachtree Restaurant serves Georgia quail and prime roast beef. Rich's Magnolia Tea Room has southern fried chicken and chicken and pecan pie, while The Luau has polynesian atmosphere and food.

future meetings

1959—MEETINGS—A.I.Ch.E.

• San Francisco, Calif., December 6-9, 1959. Sheraton Palace. **A.I.Ch.E. Annual Meeting.** See page 201.

1959—Non-A.I.Ch.E.

• Paris, France. Dec. 9-11, 1959. Hotel de Societe des Ingenieurs Civils de France, 19 Rue Blanche. **Conf. on Machine Noise.** Write: Attn. Secy. of Society, 19 Rue Blanche.

• Stanford, California. June 15-17, 1959. At Stanford Univ. **1960 Heat Transfer & Fluid Mechanics Inst.** Abstr. deadline: Dec. 1, 1959. Final papers by Feb. 15, 1960; to Papers Comm. Co-Chmn.: W. G. Vincenti, Dept. Aero. Eng. & W. C. Reynolds, Dept. Mech. Eng., Stanford Univ.

1960—MEETINGS—A.I.Ch.E.

• Atlanta, Ga., Feb. 21-24, 1960. Hotel Biltmore. **A.I.Ch.E. National Meeting.** Technical Program Chairman: F. Bellinger, Georgia Tech. 225 North Avenue, N. W., Atlanta 13, Ga. **Student Program:** H. C. Lewis, School of Ch.E., Georgia Tech., Atlanta 13, Ga. **Kinetics,** C. D. Holland, Ch.E. Dept. Texas A&M, College Sta., Tex.; **Pesticides,** (2 sessions), D. J. Porter, Diamond Alkali, Box 348, Painesville, Ohio; **Nuclear Feed Materials Processing,** D. S. Arnold, American Potash & Chemicals Co. Henderson Nev.; **The Textile Industry,** J. E. Warren, Chem. Div., Goodyear Tire & Rubber Co. Akron 16, Ohio; **High Temperature-Pressure Technology,** H. R. Batchelder, Battelle Memorial Inst. 505 King Ave.; Columbus 1, Ohio; **Mass Transfer Applications in Waste Treatment,** W. W. Eckenfelder, Manhattan College, Riverdale, N. Y. 71, N.Y.; **Filtration,** F. M. Tiller, Dean Coll. of Eng., U. of Houston, Houston 4, Tex.; **Mineral Engineering,** W. A. Koehler, W. Virginia U., Morgantown, W. Va.; **Missiles and Rockets,** R. B. Filbert, Jr., Battelle Memorial Inst., 505 King Ave., Columbus 1, O.; **Selected Papers** (4 sessions **Bio-Engrg., Engrg. Education, Petroleum-Solvents, Management** themes), R. J. Kyle, Eng. Exp. Sta., Georgia Tech, Atlanta 13, Ga.

• Mexico City, Mexico. June 19-22, 1960. Hotel Del Prado. **A.I.Ch.E. National Meeting**—Tech. Prog. Chmn.: O. E. Montes, Northern Nat. Gas Co., 2223 Dodge St., Omaha 1, Nebr. **Chemical Engineering in Latin America**—John Mayurnik, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. **Petroleum and Natural Gas Processing in Mexico & Latin America**—P. W. Jessen, Dept. Petroleum Eng., U. of Texas, Austin, Tex. **Financing International Projects: Optimization-Pitfalls & Potentials**—W. M. Carlson, Eng. Dept., Dupont, Wilmington 98, Del. **Chemical Engineering Education in the Americas**—W. R. Marshall, Jr., U. of Wisconsin, Madison 6, Wisc.; **Food and Biochemicals**—E. L. Gaden, Ch.E. Dept., Columbia U., New York 27, N. Y. **Minerals and Metals**—D. B. Coghlan, Foote Mineral Co., Berwyn, Pa. **Transfer Processes in Two-Phase Systems**—S. G. Bankoff, Northwestern Univ., Evanston, Ill. **Distillation Equipment**—R. Katzen, 3735 Dogwood Lane, Cincinnati, O. **Pilot Plants**—J. T. Cumming, Penn College, Cleveland 15, Ohio. **Construction & Operating Costs for Latin American Projects**—R. Voorhees, Union Carbide Devel. Co., 30 E. 42d St., N. Y. 17, N. Y. **Selected Papers**—J. A. Samaniego, Shell Devel. Co., Emeryville, Cal.

Deadline for papers: January 19, 1960.

• Moscow, USSR. June, 1960. **1st Congress of International Fed., Automatic Control.** To cover areas of **Theory, Hardware & Applications of Automatic Control.** U. S. participation sponsored by American Automatic Control Council. Affiliated societies: **A.I.Ch.E., ASME, AIEE, IRE, ISA.** A.I.Ch.E. Chmn.: D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.

• Buffalo, N. Y., Aug 14-17, 1960. Statler Hilton Hotel. **4th National Heat Transfer Conference & Exhibit.** Sponsored by **A.I.Ch.E. & ASME.** A.I.Ch.E. papers to S. W. Churchill, U. of Mich., Ann Arbor, Mich. **ASME** papers to J. P. Hartnett, U. of Minnesota, Minneapolis, Minn. Exhibit info to P. A. Joculvar, A.I.Ch.E., 25 West 45 St., N. Y. 36, N. Y.

• Tulsa, Okla., Sept. 25-28, 1960. Hotel Mayo. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: K. H. Hachmuth, Phillips Petroleum Co. Bartlesville, Okla. **Transport Processes in Petroleum Recovery**—L. P. Whorton, Atlantic Refining, Box 2819, Dallas 1, Texas. **Natural Gas & Natural Gas Liquids**—R. L. Huntington, U. of Oklahoma, Norman, Okla. **Advances in Refinery Technology**—W. C. Offutt, Gulf R&D Co., P. O. Drawer 2038, Pittsburgh 30, Pa. **Petrochemicals**—C. V. Foster, Continental Oil Co., Ponca City, Okla. & H. L. Hays, Phillips Chem. Co., Bartlesville, Okla. **Piloting, or Why**

continued on page 104

A MAJOR NEW SOURCE OF FRASCH SULPHUR

FIRST OFFSHORE SULPHUR MINE WILL TAP ONE OF THE WORLD'S LARGEST DEPOSITS

Freeport's Grand Isle project—seven miles off the coast of Louisiana in 50 feet of water—is unique; it incorporates many firsts and it represents pioneering in the true sense. ▪ Its real import, however, is that it extends far into the future the available reserves of low-priced Frasch sulphur. ▪ At present, sulphur is in good supply. But, since reserves cannot be found at will nor mines turned on like faucets, we must develop sufficient productive capacity well in advance to meet the much greater demand for sulphur anticipated in the coming years. ▪ Our reserves are the highest in our forty-seven-year history—certainly an assurance to our customers of an unfailing supply for their long-term needs.

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future meetings

from page 102

Buy the Restaurant When All You Need is a Meal—R. E. Weis, Phillips Pet. Co., Bartlesville, Okla. & D. Popovac, Continental Oil Co., Ponca City, Okla. **Corrosion & Materials of Construction**—W. A. Luce, The Duriron Co., P.O. Box 1019, Dayton 1, O., & M. S. Worley, Black, Sivalls & Bryson, P.O. Box 1714, Oklahoma City, Okla. **Statistics and Numerical Methods Applied to Engineering**—R. L. Heiny, 2709 Jefferson, Midland, Mich. **Air & Ammonia Plant Safety**—L. T. Wright, Standard Oil (Ind.), Whiting, Indiana. **Refinery & Natural Gasoline Plant Safety; Processing Agricultural Products**—A. Rose, Tex. Eng. Exp. Sta., Tex. A&M, Coll. Sta., Tex. **Area Industries; Chemical Reactions Induced or Modified by Radiation**—J. J. Martin, Ch.E. Dept., U. of Mich., Ann Arbor, Mich. **Conservation & Utilization of Water**—F. J. Lockhart, Ch.E. Dept., U. of So. Cal., 3551 University Ave., Los Angeles 7, Cal. **Foams**—C. S. Grove, Jr., Syracuse U., Syracuse 10, N. Y. & R. L. Tuve, U.S. Naval Rsch. Lab., Wash. 25, D.C. **Computers as a Management Tool**—R. Cziner, Grace Chem. Co., 3 Hanover Square, New York 4, N. Y. **Non-Newtonian Fluid Mechanics**—A. B. Metzner, U. of Delaware, Newark, Del. **Student Program. Selected Papers.**

Deadline for papers: May 2, 1960.

• Washington, D. C. Dec. 4-7, 1960. Statler Hotel. **A.I.Ch.E. Annual Meeting.** Tech. Prog. Chmn., D. O. Myatt, Atlantic Research Corp., Alexandria, Va.

Tentative Program framework: **Chemical Engineering in Govt. Programs. Agency Oriented: Nuclear Energy, Health and Education; Agriculture; Foreign Assistance Programs; Resource Development; Utilization and Reclamation; Naval Warfare Technology; Land Warfare Technology; Chemical Warfare, and Basic Research.** Subject Oriented: **Doing Business with the Government; Fluid Particles and Aerosols; Combustion; Materials Deterioration; New Process Techniques; Unsteady State Instrumentation; Computer Control of Processing Units; Missiles and Rockets; Design Techniques for Very Large Systems; Information and Communication; Characteristics of Portable and Expendable Plants and Equipment.**

Deadlines for papers: July 5, 1960.

1960—Non-A.I.Ch.E.

• Pittsburgh, Pa., 1st Week March, 1960. **ASTM E13 Committee: Technical Symposium on Fluorescence.** Theory and application of fluorescence or phosphorescence. Jos. W. Goldzicher, Southwest Foundation for Research & Education, P.O. Box 2296, San Antonio, Texas.

1961—MEETINGS—A.I.Ch.E.

• New Orleans, La. Feb. 26-Mar. 1, 1961. Hotel Roosevelt. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: H. L. Malakoff, Petroleum Chem. P.O. Box 6, New Orleans 6, La. **Kinetics of Catalytic Reaction; Brainstorming Technical Problems; Petrochemicals—Future of the Industry on Gulf Coast; Future Processing Technologies in the Petroleum Industry; Education and Professionalism; Mathematics in Chemical Engineering; Liquid—Liquid Extractions; New Processes in the Area; Water from Sea Water; Materials of Construction; Evaluation of Research & Development Projects; Flow Through Porous Media.**

Deadline for papers: Sept. 5, 1960.

• Cleveland, O., May 7-10 1961. Sheraton-Cleveland. **A.I.Ch.E. National Meeting.** Tech. Prog. Chmn.: R. P. Dinsmore, Goodyear Tire & Rubber Co., Akron 16, O.

Unscheduled Symposia

Correspondence on proposed papers is invited. Address communications to the Program Chairman listed with each symposium below.

Computers in Optimum Design of Process Equipment—Chen-Jung Huang, Dept. of Chem. Eng., Univ. of Houston, Cullen Blvd., Houston 4, Texas.

Solar Energy Research—J. A. Duffie, Director of Solar Energy Laboratory, Univ. of Wisconsin, Madison, Wis.

Hydrometallurgy—Chemistry of Solvent Extraction: G. H. Beyer, Dept. of Chem. Eng., Univ. Mo., Columbus, Mo.

Process Dynamics as They Affect Automatic Control—D. M. Boyd, Universal Oil Prods., Des Plaines, Ill.

Nuclear Chemical Plant Safety—C. E. Dryden, Ohio State U., Columbus, O.

Nuclear Reactor Operations—R. L. Cummings, Atomics International, P. O. Box 309, Canoga Park, Cal.

Drying—R. E. Peck, Ill. Inst. of Tech., 330 So. Federal, Chicago, Ill.

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SIMPLE — Only two more parts than in conventional disc bowl... no nozzles, valves, bolts, or springs to complicate assembly and disassembly.

NEW DRIVE — Heavy duty 40 hp motor. No clutch, no gears.

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"Around-the-clock" operation — up to six weeks, depending on product... up to 8000 gph capacity.

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De-sludging cycle controlled by timing unit... choice of complete or partial de-sludging.

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Stainless steel construction throughout bowl and all other liquid and sludge contact parts... bowl designed for complete self-cleaning... CIP cleaning possible.

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For more information, turn to Data Service card, circle No. 61

The following 2 pages that appear to be missing are reader service cards and have been removed.

Spray drying NEWS

RECOGNIZED LEADER IN SPRAY DRYING SINCE 1926

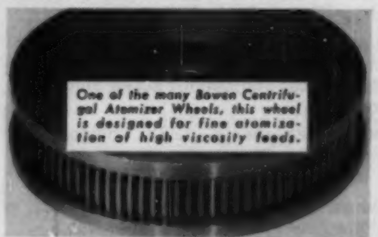
VOLUME 1, NO. 3

Bowen Centrifugal Spray Machine built to stand punishment of 'round-the-clock production

DESIGN AND CONSTRUCTION FEATURES ASSURE DEPENDABLE OPERATION WITH MINIMUM ATTENTION

Long acclaimed by the process industries as the most sturdy and dependable drive mechanism for centrifugal atomization, the Bowen Centrifugal Spray Machine is ideally suited for spray drying chemical products under automatically-controlled, high-tonnage production conditions.

EXCEPTIONAL OPERATING FLEXIBILITY—Whether solutions, slurries or emulsions are being spray dried, the Bowen Spray Machine enables purchasers of Bowen Spray Dryers to capitalize fully on the inherent benefits of the centrifugal atomizing technique. For example: (1) Feed rates—hence, production rates—may be adjusted over a broad operating range with no perceptible change in finished product characteristics. (2) Product particle size may be altered easily by changing spray machine speed. (3) In addition, other product characteristics—such as bulk density and particle size distribution—may be varied to suit requirements by means of interchangeable Bowen Atomizer Wheels of different patented designs. (see cut)



One of the many Bowen Centrifugal Atomizer Wheels, this wheel is designed for fine atomization of high viscosity feeds.

SIMPLE DIRECT-DRIVE DESIGN—Unique, yet simple in design, the Bowen Spray Machine is a compact, self-contained unit constructed for *continuous* high-temperature operation. Its built-in high frequency motor is protected by a sturdy water-jacketed housing through which a corrosion-resistant feed pipe delivers feed material to a rapidly spinning atomizer wheel. This centrifugal wheel is directly

Compact and self-contained, the Bowen Centrifugal Spray Machine can be taken out of service—for wheel changes, inspection, etc.—and be back in production within minutes.

mounted on the short, rugged main drive shaft of the motor to assure positive, efficient operation. A frequency converter set (which may be safely located out of hot, dusty and otherwise hazardous process areas) furnishes the high frequency current needed for machine operation. Frequencies can be precisely selected to provide any desired atomizer wheel speed between 4,000 rpm and 20,000 rpm.

MINIMUM ATTENTION REQUIRED—Automatic control of a constant feed rate is easily accomplished since feed introduction depends on simple gravity flow or easily-maintained low pressures. There are no pump-pressure fluctuations to cause operating headaches. This—coupled with the steady, unwavering speed of the high-frequency motor driven centrifugal wheel—guarantees day-in and day-out production of uniform product with minimum operator attention. And unlike centrifugal machines employing standard-speed motors, the Bowen machine has no complicated high-speed belt or gear system that invariably introduces complex, time-consuming problems of balancing, alignment, shaft distortion and excessive wear. The simple Bowen direct-drive design avoids these troublesome, production-halting problems and eliminates the need for frequent machine maintenance and repair.

For more information on the Bowen Spray Machine, request Bulletin No. 51.

SPEAKING FOR BOWEN

DONALD W. BELCHER, Bowen V. P. in charge of Engineering, *discusses three methods of atomization used in various Bowen spray dryer designs.*

ATOMIZATION TECHNIQUES

Atomization is the heart of the spray drying process. It is the means by which high liquid surface-to-mass ratios are attained for achieving the extremely rapid rates of evaporation essential to an efficient spray drying operation. Three methods are commonly employed:

PRESSURE NOZZLE ATOMIZATION—*Here, atomization energy is provided by fluid pressure. Liquid feed material is introduced to the spray dryer under high pressures through specially-designed nozzles. This method is restricted to solutions and uniform, fine-particle slurries. To a limited degree, variations in product characteristics may be obtained by changing nozzle designs and operating pressures.*

CENTRIFUGAL ATOMIZATION—*This method utilizes the energy of centrifugal force to atomize the feed material. Any solution or slurry that can be pumped can be handled by this method. A rapidly spinning wheel accelerates the feed into a thin sheet that leaves the wheel edge at speeds ranging from 150 to 450 mph. The tearing impact of the feed against the drying air atomizes both low and high viscosity materials into a fog-like mist. The centrifugal technique and its advantages are described further in the adjoining article.*

PNEUMATIC NOZZLE ATOMIZATION—*Sometimes called two-fluid nozzle atomization, this method obtains its energy for feed atomization from the pressure of a second fluid, usually air or steam. It is particularly well suited for handling abrasive feeds provided the nozzle is properly designed. Generally, this method is limited to low production capacity operations.*

Check items desired, clip and mail with your name, title and company address to Bowen Engineering, Inc., North Branch 13, N. J.

☐ Bowen Spray Machine Bulletin No. 51

☐ Bowen Test Laboratory Booklet

Information on the feasibility of spray drying:

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For more information, turn to Data Service card, circle No. 102

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 108*

Gauges (p. 14). Technical data on many types from Jerguson Gage & Valve. **Circle 95.**

Grinding Equipment (p. 153). Data from Pulverizing Machinery Div., Metals Disintegrating on grinding, air conveying, and dust collection equipment and services. **Circle 96.**

Heads (p. 115). Spun or pressed heads in diameters from 9 in. to 19 ft., gages from 3/16 to 6 in. Colorado Fuel and Iron. **Circle 103.**

Heaters, industrial (p. 199). Bulletin 1043C, "Gradiation Heating for Petroleum and Chemical Processing" from Selas. **Circle 141.**

Heat Exchangers (p. 203). Schutte and Koerting specialties in custom-built heat transfer apparatus. Technical info. **Circle 133.**

Heat Exchangers, air-cooled (p. 30). Catalog 557 from Young Radiator describes "Horizontal Core Units," high-capacity, forced-draft, air-cooled heat exchangers. **Circle 27.**

Heat Exchangers, panel coil-type (p. 218). Technical data from Dean Products. **Circle 148.**

Heat Transfer Equipment (p. 176). Heat Exchanger Bulletin 158-HE from Doyle & Roth. **Circle 150.**

Indicator, shaft motion (p. 216). Bulletin RG-16 from Bin-Dicator describes the "Roto-Guard." **Circle 2.**

Jet-Venturi Equipment (p. 141). Data from Croll-Reynolds on many types. **Circle 92.**

Joints, expansion, packless (p. 175). Bulletin 59-50 from Adsco Div., Yuba Consolidated Industries, gives details of "Corroflex" joints. **Circle 149.**

Meter, tank contents (p. 204). Data from Uehling Instrument on the "Tankometer," for measuring tank contents from any distance. **Circle 24.**

Mills, ball, vibrating (p. 26). Continuous and batch models in pilot-plant and production sizes. Details from Schutz-O'Neill. **Circle 75.**

Mills, grinding, fluid-energy (p. 211). In 8 custom-made sizes, mill diameters from 2 to 36 in. Data from Jet Pulverizer. **Circle 108.**

Mills, grinding, fluid energy (p. 220). Full details from Sturtevant Mill on the "Micronizer." **Circle 39.**

Mills, grinding, impact (p. 219). Complete technical data from Entoleter, Div. of Safety Industries. **Circle 40.**

Mills, hammer (p. 208). Bulletin H-850 from Gruendler Crusher and Pulverizer. **Circle 107.**

Mixers (p. 32-33). "Handbook on Mulling" from Simpson Mix-Muller Div., National Engineering. **Circle 99.**

Mixers (p. 97). Catalog A-19 from Philadelphia Gear. **Circle 165.**

Mixers (p. 196). Bulletin 192 from Sprout-Waldron describes special mixer for polycarbonate resin. **Circle 22.**

Mixers (p. 212). Portable, heavy-duty, fixed mounted, propeller, turbine types. Data from Eastern Industries. **Circle 59.**

Mixers (p. OBC). Technical info from Mixing Equipment Co. **Circle 53.**

Nozzles, spray (p. 212). Comprehensive Catalog from Binks Mfg. **Circle 38.**

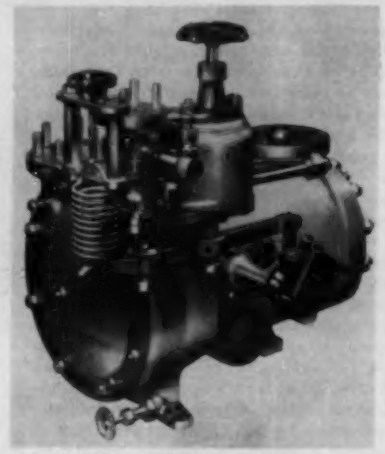
Nozzles, spray (p. 217). Over 12,000 standard models. Catalog 24 from Spraying Systems. **Circle 8.**

Packings (p. 218). Technical data from Greene, Tweed on "Palmetto" packings. **Circle 7.**

Packing, column (p. 210). Bulletins and technical info on "Goodloe" packing from Packed Column Corp. **Circle 20.**

Piping, corrosion-resistant (p. 27). Bulletin TS-1A from Resistoflex gives info on "Fluoroflex-TS" chemically inert piping. **Circle 81.**

DEVELOPMENT OF THE MONTH



PACKAGED TURBO PUMP

(Circle 606 on Data Post Card).

The new IND pump, made by Coffin Turbo Pump, features turbine, pump, and controls in one integral, matched unit. All parts are 100% interchangeable. It is a high-speed, single-stage, diffuser-type of extremely simple construction. Positive lubrication is assured by oil splash rings, incorporating an oil dam system.

Capacity is 180 gal./min., discharge pressures go up to 350 lb./sq. in. For technical bulletin with all details, Circle 606 on Data Post Card.

Piping, corrosion-resistant (p. 186). Data and Information Bulletin from Fibercast. **Circle 14.**

Piping, corrosion-resistant, armored (p. 169). Details from Haveg. **Circle 55.**

Piping, jacketed (p. 215). Bulletin J-57 from Hetherington & Berner. **Circle 58.**

Process Equipment, graphite (p. 173). Data from National Carbon on graphite heat exchangers, entrainment separators, valves. **Circle 154.**

Processor, thin-film (p. 198). Kontro offers info on the "Ajust-O-Film," thin-film, centrifugally-wiped chemical processor. **Circle 82.**

Pumps (p. 177). Capacities to 1,000 gal./min., pressures to 300 lb./sq.in., heads to 430 ft., temperatures to 450°F. Data from Peerless Pump Div., Food Machinery and Chemical. **Circle 71.**

Pumps, chemical (p. 155). Technical data from Dean Brothers Pumps on new "pH" pump, available in 28 sizes, 14 alloys. **Circle 94.**

Pumps, controlled-volume (p. 200). Capacities to 24 gal./min., pressures to 6,800 lb./sq. in. Bulletin 440 from Lapp Insulator. **Circle 18.**

Pumps, controlled-volume (p. IBC). Catalog 553-1 from Milton Roy is general introduction to controlled volume pumping. **Circle 42.**

Pump, metering, packless (p. 146). Specification Sheet from Hills-McCanna gives full details. **Circle 161.**

Pumps, peristaltic action (p. 224). Size and capacity info from Sigmamotor. **Circle 37.**

Pumps, plastic (p. 203). No stuffing box, no shaft seals. Catalog from Vanton Pump & Equipment. **Circle 3.**

Pumps, process (p. 185). Standard models from 25 to 2,500 hp., pressures to 30,000 lb./sq. in. Data from Aldrich Pump. **Circle 127.**

Pumps, screw (p. 188). Bulletin 206 from Warren Pumps gives details of external gear and bearing screw pumps. **Circle 25.**

Pumps, sealless (p. 123). Composite Curve from Chempump shows range of models and sizes. **Circle 131.**

Pumps, turbine-type (p. 12). Pumps, turbine, controls in single unit. Capacities to 180 gal./min., discharge pressure to 350 lb./sq. in., temp. to 300°F. Data from Coffin Turbo Pump. **Circle 162.**

Reactors (p. 118). Technical info from Bethlehem Foundry & Machinery. **Circle 163-2.**

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For more information, turn to Data Service card, circle No. 78

CEP'S DATA SERVICE—Subject guide to advertised products and services

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 110*

Recorder, plastic flow (p. 214). The "Plastograph," made by C. W. Brabender Instruments, records plastic flow of all polymers at temperatures to 600°F. Technical Bulletins. **Circle 60.**

Rectifiers (p. 221). Sel-Rex offers Guide to Industrial Rectifier Equipment. **Circle 23.**

Rotameters, transmitting, pneumatic (p. 102). Bulletin 18N from Schutte and Koerting. **Circle 70.**

Rotameter-Transmitter (p. 111). Data from Brooks Rotameter on new "straight-thru" model. **Circle 78.**

Screens, vibrating (p. 204). Complete Catalog Data from Syntron. **Circle 132.**

Separators, entrainment (p. 4). Improve performance of distillation equipment, vacuum towers scrubbers, evaporators. Data from Otto H. York on "Demisters." **Circle 152.**

Separators, entrainment (p. 36). High efficiency over entire range of flow. Data from Peerless Mfg. **Circle 21.**

Separators, entrainment (p. 125-126). Bulletins from Otto H. York. **Circle 139.**

Sifters, rotary (p. 5). For single or multiple separations, down to 325 mesh. Details from B. F. Gump. **Circle 34.**

Snubber, flow-check (p. 210). Bulletin C-11 from Chemiquip. **Circle 104.**

Stills, high-vacuum (p. 135). Bulletin 3-1 from Consolidated Vacuum gives details of equipment, data on sample testing service. **Circle 76.**

Storage Vessels, liquid oxygen (p. 121). Data from Hofman Laboratories. **Circle 166.**

Tanks (p. 184). New 16-page Catalog from Littleford Bros. **Circle 69.**

Tanks, wood, polymer-lined (p. 215). Data from Wendnagel on "Polycel" tanks. **Circle 35.**

Thickeners, spiral rake (p. 31). Laboratory testing service available at Denver Equipment for selection of proper size thickener. **Circle 98.**

Valves (p. 28-29). Data from Wm. Powell on process valves of every type in all metals and alloys. **Circle 80.**

Valves, ball (p. 147). Booklet 1100 from Hills-McCanna. **Circle 100.**

Valves (p. 183). Bulletin 150 from DeZurik. **Circle 62.**

Valves, control, small (p. 221). Catalog B-1 from George W. Dahl on "Bantam" on-off and throttling control valves. **Circle 118.**

Valves, high-pressure (p. 220). Catalog from American Instrument details high-pressure valves, tubing, fitting. **Circle 91.**

Valves, plug, jacketed, air-operated (p. 217). Catalog Supplement 356-S from Parks-Cramer. **Circle 9.**

Valves, plug, non-lubricated (p. 101). In ductile iron, or stainless, ½ to 2 in. sizes. Bulletin V/1 from Duriron. **Circle 52.**

Viscometer (p. 104). Data from Brookfield Engineering Laboratories on the "Viscometran." **Circle 79.**

SUBJECT GUIDE to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT

301 Agglomerating Equipment. Bulletin 540 from Blaw-Knox describes the "Instantizer" which forms spray-dried powders into agglomerated clusters for easy reconstitution.

302 Centrifuges, continuous. Bulletin 1284 from Sharples describes complete line of separation equipment.

303 Compressors, air-cooled. Booklet "Compressed Air Fundamentals" from Ingersoll-Rand applies to models from ½ through 20 hp.

304 Computers, analog. Southwestern Industrial Electronics offers Brochure on the CM-2, specially adapted for chemical and petrochemical industry use.

305 Coolers, cascade, graphite. Bulletin 537 from Falls Industries gives dimensions of standard models, selection guide.

306 Dust Collector, mechanical. Details from Research-Cottrell on new and improved involute design. Technical Bulletin 300.

continued on page 114

MATERIALS

344 Alloys, high-temperature. Bulletins from Kelsey-Hayes, Metals Div., describe UDIMET 700 and UDIMET 41, new "super-alloys." Physical and chemical properties, isostress curves.

345 Antifoams, silicone. Bulletin CDS-204 from General Electric, Silicone Prod. Div., gives data on industrial foaming problems.

346 Chemicals, industrial. Products List, Bulletin 100-C from Hooker Chemical gives descriptions, physical data, uses, shipping data on wide range of chemicals.

347 Chemicals, industrial. Bulletin P-102 from Eastman Chemical Products gives properties, shipping info on complete list of industrial and specialty chemicals.

348 Chemicals, industrial. Dow Chemical offers new 44-page listing with properties and uses of about 375 industrial, pharamceutical, and agricultural chemicals. Special section on plastics and coatings.

continued on page 114

SERVICES

363 Design and Construction, maleic anhydride plants. Case History Bulletin from Scientific Design details process for production of maleic by direct air oxidation of benzene.

364 Explosion Prevention. Bulletin 173 from Clark Bros. presents latest findings on mechanism of explosions in pipelines and compressor starting air lines.

365 Fabrication, process equipment. Catalog G-159 from Process Engineering and Machine covers pressure vessels, heat exchangers, distillation columns, reactors.

366 Fabrication, process equipment. Bulletin 1417 from Read Standard covers many types of mixers and filters.

367 Fabrication, process equipment. Catalog from Manning & Lewis covers chemical process and heat exchange equipment.

368 Heat Loss Calculations. Baldwin-Ehret-Hill offers File Folder on "How to Compute Heat Losses Graphically."

For more information, turn to Data Service card, circle No. 19

CEP'S DATA SERVICE—Subject guide to free technical literature

CIRCLE CORRESPONDING NUMBERS ON DATA SERVICE CARD

EQUIPMENT *from page 112*

307 Fans, plastic. All parts in contact with fumes made of solid, unplasticized PVC. Technical data from Heil Process Equipment.

308 Feeder, high-capacity. Bulletin 35.20-2 from B-I-F Industries gives details of new "Omega" belt gravimetric feeder. Dimensional drawings, list of accessories.

309 Filters, cloth discharge. Automatic removal, washing, replacement of fabric medium on drum-type filter. Details in Bulletin from Peterson Filters and Engineering.

310 Filters, tungsten carbide. For extremely high-temperature work. Data from Engineered Materials.

311 Filter Pump Units. From 50 to 2,700 gal./min., pH from 0 to 14. Bulletin M-1 from Sethco Mfg.

312 Gas Drying Equipment. New Bulletin from Gas Atmospheres describes equipment for removal of moisture from low-pressure gas or air streams.

314 Gauge, high-pressure. In 12 ranges from 1,000 to 100,000 lb/sq.in. Technical info and prices from Astra.

315 Heaters, deaerating, spray-type. Bulletin WC-101C from Graver Water Conditioning discusses process and equipment, design features, accessories.

316 Homogenizers. Buschman Products offers 4 new models of the "Jet-Mogenizer" with 3 stages of homogenization, capacities from 150 to 500 gal./hr. Technical info.

317 Instruments, control. Controller-positioner-valve combination with automatic reset feature. Info from Robertshaw-Fulton Controls.

318 Materials Handling Systems, pneumatic. Superior Separator offers Bulletin with all technical details of the "Fluidizer."

319 Mills, colloid. Emulsify, disperse, homogenize, suspend. Bulletin from Chemicolloid Laboratories.

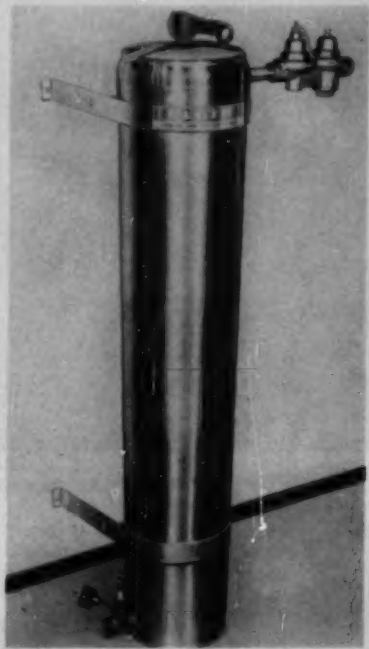
320 Mills, grinding, fluid energy. Bulletin from Fluid Energy Process & Equipment on the "Jet-O-Mizer."

321 Mixers, vertical-drive. Selection table in Bulletin from Stockdale Engineering, US Mixer Div.

322 Nozzles, spray. Catalog from Wm. Steinen Mfg. describes complete line.

323 Ovens, industrial. Complete Catalog from Despatch Oven details laboratory, pilot-plant, and batch-type production ovens.

DEVELOPMENT OF THE MONTH



EXCHANGEABLE REFILL DEIONIZER

(Circle 605 on Data Post Card).

A ompact new deionizer, the "Junior 120" made by Elgin Softener, will deliver up to 120 gallons of deionized water per hour.

Included with the unit is a service whereby removable bags of mixed ion exchange resin, when exhausted, are simply lifted out and exchanged for factory-regenerated refills. This eliminates the task of regeneration, the expense of disposable resin cartridges, and delays in waiting for replaceable units.

The new deionizer is said to be ideally sized for applications which do not justify a large deionizer, but which are too large for portable or cartridge units capacities—laboratory, research, and smaller commercial installations. Cost is claimed much less than by distillation. For full details, Circle 605 on Data Post Card.

324 Power-Heat Unit. Bulletin B-3240 from Titusville Iron Works gives details of the "Titan," new 3-pass power and heating unit with all wet-back construction. Sizes to 900 hp.

325 Pumps, centrifugal. Bulletin 108 from Frederick Iron & Steel gives details of single & double suction, single & multi-stage models.

326 Pumps, process. Info from Dean Brothers Pumps on new "pH" pump, available in 14 sizes, 14 different alloys.

327 Pumps, proportioning, multiple-head. For multi-liquid blending in semi-batch and complete automatic chemical processing. Data from Lapp Insulator.

continued on page 116

MATERIALS *from page 112*

349 Dimethylacetamide. General information Bulletin from Du Pont gives properties, reactions, applications of new polar solvent.

350 Latices. New 30-page Bulletin from Koppers, Plastics Div., covers product performance of "Dylex K-31," improved styrene-butadiene copolymer latex, designed for interior paints.

351 Mastics. Reference Chart from Benjamin Foster gives description, coverage range, drying time, service temperature, flash point, flame spread, solvent for clean-up, water vapor permeance.

352 Packings. Comprehensive Engineering Handbook from Greene, Tweed gives details of "Palmetto" molded packings, G-T Ring.

353 Packing, column, Nylon. Data from Packed Column Corp. on "Goodloe" packing, knitted of Nylon monofilaments.

354 Phenolics. New 16-page Reference Booklet "Facts on Phenolics" from Hooker Chemical.

356 Polyethylene, rigid. Phillips Chemical offers new 26-page Brochure on applications and characteristics of "Marlex" rigid polyethylene.

357 Polyvinyl Chloride, rigid. New Catalog from Kaykor Industries gives properties and applications of rigid PVC products.

358 Propellants, aerosol. Technical article on "Blending of Aerosol Propellants" from Union Carbide Chemicals.

359 Sealing Compound. Data from Crane Packing on "Plastic Lead Seal" pipe joint and thread sealing compound, for temperatures to 550°F, pressures to 6,000 lb./sq.in.

360 Steels, specialty. Carpenter Steel offers 40-page Buyers Guide on specialty steel products.

361 Tracers, radioactive. Bulletin 650 from U.S. Nuclear is comprehensive list of physical specifications of industrial radioactive tracers.

362 Wire Cloth. New Bulletin from Newark Wire Cloth details wire cloth in all metals, all meshes, all weaves, all widths.

Nationwide stocks give you prompt delivery...

on CF&I-CLAYMONT HEADS

This giant steelman – the Image of CF&I – represents *service* for CF&I customers coast to coast. One example of this service is the inventory of Claymont Steel Head stocks maintained at strategically-located CF&I warehouses.

Elliptical Heads are stocked at Houston • Los Angeles • San Leandro, Calif. • Tulsa

Inside Diameters–24" to 120"
Specifications–A-285-C and A-212-B Firebox Steels

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Outside Diameters–18" to 120"
Specifications – ASTM A-285-C Flange and Firebox Steel; Hot Pressing Steel (for Standard Heads only)

Fittings are stocked at Chicago • Claymont, Del. • Houston • Tulsa

Manhole and Handhole Fittings • Elliptical Manhole Rings for Low Pressure Vessels • Storage Tank Manhole Frames and Covers

Claymont is completely equipped to produce spun or pressed heads in diameters from 9" to 19'... in gages from 3/16" to 6"... in all shapes and a complete range of ferrous and non-ferrous metals.

Complete details on Claymont Head stocks are published and distributed monthly. If you are not now receiving this stock list, and would like to, just notify the CF&I sales office nearest you.

CF&I-CLAYMONT PRODUCTS: Carbon Steel Plates • Alloy Steel Plates • CF&I Lectro-Clad Nickel Plated Steel Plates • Clay-Loy High Strength Low Alloy Steel Plates • Flanged and Dished Heads • Pressed Steel Shapes • Manhole Fittings, Covers and Saddles • Fabricated Steel Plate Products • Large Diameter API Pipe

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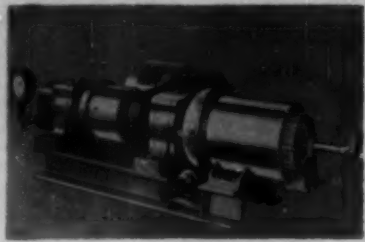
7083-A

For more information, turn to Data Service card, circle No. 103

Data Service

continued

DEVELOPMENT OF THE MONTH



SOLID-BOWL CENTRIFUGAL
(Circle 608 on Data Post Card).
This small unit operates at speeds up to 6,000 rev./min. It is recommended for separations involving moderate volumes, limited space, or extra powerful separation force. It is also suggested as a handy tool for experimental and development operation. Both bowl and conveyer are cantilever-supported for quick servicing.

For details from Bird Machine, Circle 608 on Data Post Card.

EQUIPMENT *from page 114*

328 Pumps, sump, acid-proof. Handles flotation products, solution transfer, frothy liquids, acid pulps, slurries. Capacities 10 to 250 gal./min. Bulletin SP-057 from Galigher.

329 Pyrometers, surface. Technical data and Price List from Cambridge Instrument.

330 Refrigeration Equipment. Bulletin 250 from Frick describes industrial refrigeration installations.

331 Seals, mechanical. Bulletin CP551 describes the "Chempro" mechanical seal, for pumps, agitators, autoclaves. Chemical and Power Products.

332 Sight Glasses. Swift Glass offers heat-resistant sight glasses with drilled holes from 1/8 to 2 in. diameter.

333 Size-Reduction Equipment. Bulletin 350 from F. J. Stokes describes new "Tornado" mill, and Model 43-B oscillating granulator.

334 Tanks, glassed-steel. Bulletin 975 from Pfaudler gives physical specifications, applications.

335 Tubing, special metals. New Special Analysis Memo from Superior Tube describes small tubing in columbium, tantalum, vanadium.

336 Valves, foot, plastic. In sizes from ½ to 2 in. Data from Chemtrol.

337 Valves, high-pressure. Bulletin 4072 from American Instrument describes new line of high-pressure, pipe-size valves and fittings.

continued on page 118

NEW CATALYSTS

pace GIRDLER CATALYSTS' service to processors

NEW G-53 nickel hydrogenation catalyst has improved activity on first use and superior reuse properties. It has been found to be especially suited to hard-to-hydrogenate oil products.

NEW G-54 permits selective hydrogenation of acetylenes . . . offers higher activity, greater flexibility and selectivity, longer cycles between regenerations than conventional catalysts.

NEW G-49 improves slurry hydrogenation of organic compounds . . . is non-pyrophoric, highly active, will not contaminate hydrogenated product, and can be completely filtered.

NEW G-56 catalyst improves reforming of hydrocarbons . . . offers greater reforming activity, eliminates need for preactivation, maintains performance at high temperatures.

TECHNICAL SERVICE *from Girdler Catalysts is complete . . . ranges from on-the-spot Application Service to Analytical, Research and Development Services, and superior Production Service to meet your specifications.*

Several new catalysts recently developed by Girdler Catalysts offer important processing advantages. We invite you to send for samples and technical information.

These new products are the latest results of Girdler Catalysts' improvement program . . . also evident in expanded production capacity, broader field service, and top-notch technical assistance. Let Girdler Catalysts help with *your* processing problems.

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Catalysts for: Hydrogenation • Synthesis Gases • Hydrogen Generation • Desulfurization • New Catalytic Processes • Custom Applications

For more information, turn to Data Service card, circle No. 89

Data Service

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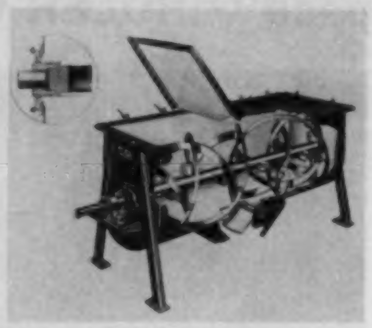
DEVELOPMENT OF THE MONTH



NEW RIBBON BLENDER

(Circle 602 on Data Post Card). Designed for extremely thorough batch mixing and blending of small amounts of ingredients into large amounts of basic material.

The unit is designed to meet all required sanitary codes, is dust-tight and easy to clean. Available in 9 models from 16 to 300 cubic foot capacities. Comes in carbon or stainless steel construction. For complete technical details from Strong-Scott Mfg. Circle 602 on Data Post Card.

EQUIPMENT *from page 116*

338 Valves, high-pressure. Catalog 759 from High Pressure Equipment details all-purpose stainless valves and fittings for pressures to 15,000 lb./sq.in.

339 Valves, nuclear. Bulletins from Automatic Switch describe radically new designs.

340 Valves, plug, spherical, lubricated. Bulletin V-607 Rev. 1 from Rockwell Mfg. gives operating features, detail drawings, specifications, dimensions.

341 Valves, pressure-reducing. Technical Folder from Atlas Valve.

342 Valves, sleeved, jacketed. Data Sheet from Continental Mfg. shows details of "Tufline" valves in new jacketed construction. In standard 150 and 300 lb. two- and three-way bottom entry designs.

343 Valves, solenoid. Bulletin from Hoke gives specifications, technical data, ordering info.

A.I.Ch.E. Membership

Brochure—"Know Your Institute"—tells objective aim and benefits to chemical engineers who join this nation-wide organization, includes membership blank. Circle number 600 on Data Post Card.

industrial news

Direct reduction process for sponge iron

New plant now under construction in Mexico will use the HyL process, M. W. Kellogg is exclusive licensor

The HyL production process will be used at a 500-ton-a-day sponge iron plant now under construction for Fierro Esponja, Monterrey, Mexico. The company, an affiliate of Jojalata y Lamina, one of Mexico's leading steel producers, also operates a 200-ton-a-day plant on an adjacent site which has turned out 100,000 tons since it went into operation a year ago.

The process reduces ore by direct contact with hot reformed natural gas in five batch-type, 13-long-ton-capacity reactors. No coke is required. Two gas reforming furnaces provide the reducing gas. The sponge iron is charged to electric furnaces mixed with scrap and converted to steel. Big advantage of the HyL process is that it removes water and calcining loss. It also removes a high percentage of oxygen and sulfur from the ore, and, in addition, deposits carbon in the sponge iron.

M. W. Kellogg is exclusive licensing agent for the process, which was developed by Jojalata y Lamina.

The new plant is scheduled to go on stream in early 1960.

The sixth Midwestern Conference on Fluid Mechanics and the Fourth Midwestern Conference on Solid Mechanics met jointly at the University of Texas, Austin, Texas, on September 9-11.

Proceedings of the conference are published in two volumes one on Fluid Mechanics, and one on Solid. Copies of the proceedings are available to those not attending the conference. The cost is $12.50 per volume. Orders may be addressed to:

Engineering Institutes, Division of Extension, The University of Texas, 18th and Red River Streets, Austin, Texas.

An $18 million expansion program at Texaco's refinery at Pointe-a-Pierre, Trinidad, when completed, will increase crude oil capacity 100,000 barrels a day, to 235,000. The new units consist of a topping unit, a catalytic reformer and a hydrotreater. Construction is expected to take about a year.

A.I.Ch.E. candidates

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions. These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before December 15, 1959, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

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Cosewith, Charles, *Pittsburgh, Pa.*
Cummings, P. W., Jr., *Pensacola, Fla.*

Daly, Joseph F., *Newark, N. J.*
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George, Robert F., *Birmingham, Ala.*
Godwin, George H., Jr., *Auburn, Ala.*
Gogolin, E. Lawrence, Jr., *Harrisburg, Pa.*
Gomezplata, Albert, *College Park, Md.*
Greenawalt, Robert E., *State College, Pa.*
Gretzinger, James, *Buffalo, N. Y.*
Grill, Robert, *New York, N. Y.*

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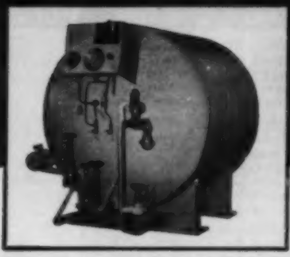
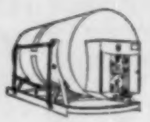


hofman Liquid Oxygen Storage Vessel Survives 40 G's in Simulated Near-Miss Impact Test!

hofman
15-gal
liquid oxygen
top-off vessel

hofman
350 gal
liquid oxygen
storage vessel



hofman
2000-gal
liquid oxygen
storage vessel

To see how a new, lightweight Hofman 150-gal. low-temperature storage vessel would stand up under battle conditions, one was bolted to a test stand which was then battered with a ton-and-a-half steel weight exerting a force of more than 130,000 lbs.

It took six mighty blows before something cracked, and even then it was not the vessel: one of the bolts holding the vessel to the test stand fractured under the onslaught, but *the Hofman liquid oxygen storage vessel remained intact and operable!*

A specially-designed, lightweight, low-loss vessel was required—*and Hofman delivered.*

Write today for catalog describing the full line of Hofman low-temperature storage and transport vessels.

hofman LABORATORIES, INC.

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Distributor Sales Company, Indiana, Michigan & Ohio, 24431 Oakhill Drive, Cleveland 17, Ohio, IVanhoe 1-5364
R. W. Fowler & Associates, Inc., Florida, 1222 Third Street, S., Jacksonville Beach, Florida, CHerry 6-2477
EXPORT DIVISION: **Southern Oxygen Company, Inc.,** 250 West 57th Street, N. Y. C., JUdson 2-6760

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A.I.Ch.E. candidates

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Hagon, D. O., *New York, N. Y.*
Hanson, William G., *Cuyahoga Falls, Ohio*
Harper, John M., *St. Louis, Mo.*
Hassel, Melvin L., *San Francisco, Calif.*
Haupt, Vincent R., *Florence, Ala.*
Hill, William T., *Texas City, Texas*
Hooper, John W., *Beaver, Pa.*
Howard, Ronald Albert, *Biddeford, Maine*
Huttenbach, Dirk E., *Dunellen, N. J.*

Jahn, George F., *Wilmington, Del.*
Jones, James Lee, Jr., *Anniston, Ala.*
Jones, Lee W., *Huntsville, Ala.*
Jones, Thomas E., *Jasper, Ala.*

Kister, Albert T., *Emeryville, Calif.*
Kuhn, John P., *Lakewood, Ohio*
Kurz, Robert A., *St. Louis, Mo.*

Layman, Richard N., *Killen, Ala.*
Liles, Arthur William, *Baton Rouge, La.*
Loo, Larry Y. S., *Palo Alto, Calif.*
Loureiro, Valentin R., *Plainfield, N. J.*
Love, William S., *Belleville, Ill.*

Mallen, James C., *Gainesville, Fla.*
Manning, Thomas J., *Texas City, Texas*
Manoff, Mark, *New York, N. Y.*
McCallister, James E., *Calvert City, Ky.*
McCombie, Thomas G. F., Jr., *St. Paul, Minn.*
Misiorowski, Richard J., *Chicago, Ill.*
Mitchell, Leo S., *Norco, La.*
Moriarty, David W., Jr., *Old Mystic, Conn.*
Munaim, Amir I., *Surat, India*
Murrin, J. Michael, *South Charleston, W. Va.*

Newcomb, Rex DeFord, *Manistee, Mich.*
Niccolls, Richard W., *Kirkwood, Mo.*

Olenicsak, Albert T., *Philadelphia, Pa.*

Pearson, Alan, *St. Louis, Mo.*
Plum, Kenneth C., *Brigham City, Utah*
Popper, Gabriel A., *Haddonfield, N. J.*
Powell, Roger William, *Akron, Ohio*
Preston, Peter J., *Lynchburg, Va.*

Quinn, James D., *Madison, Wis.*

Rahfuse, Robert V., *Cincinnati, Ohio*
Richards, James Glenn, *Baytown, Texas*
Richards, Joe M., *Salem, Ore.*
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Rubin, Jack N., *Hopewell, Va.*
Rudd, Dale, *Minneapolis, Minn.*

Samuel, William A., *Callery, Pa.*
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Seamans, Thomas F., *Chester, N. J.*
Smith, C. Wesley, *Richland, Wash.*
Stapf, Charles J., Jr., *Wilmington, Del.*
Sydow, David W., *Salt Lake City, Utah*

Terry, William C., *Pasadena, Texas*
Tetlow, Norman J., *Burlington, Iowa*
Tims, W. Denton, *Ironton, Mo.*
Trowbridge, Theodore D., *Billerica, Mass.*

Valle, Lars I., *Seattle, Wash.*
Vogt, Walter M., *St. Louis, Mo.*

Warthen, John L., *Clarksville, Md.*
Wayland, H. P., Jr., *Fredericktown, Mo.*
Weiss, Verne E., *Minneapolis, Minn.*
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Wright, Gerald D., *San Diego, Calif.*

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NEW YORK COLISEUM
NOV. 30 - DEC. 4, 1959

CEP CHEM SHOW SPECIAL

27th exposition of CHEMICAL INDUSTRIES

SIMPLIFY YOUR equipment shopping problems. Save travel time and money, wear and tear on your mental selection facilities. Come to the world's biggest single exhibition for chemical processing equipment.

In the market for pumps? Where else could you find under one roof Aldrich, Worthington, Peerless, Hills-McCanna, Ingersoll-Rand, Goulds, Vanton? Filters?—Here will be Alsop, Niagara, Shriver, Bowser, Sparkler, Komline-Sanderson, Hercules, Filtration Engineers, scores of other makers, each represented on the spot by engineers qualified to give sound technical advice.

In a whirl choosing the right centrifuge? Get help from De Laval, Pfaudler, Sharples, Tolhurst, Centrico, Bird Machine. Is your problem process control? Discuss your troubles with Minneapolis-Honeywell, B-I-F Industries, Bailey Meter, Beckman, Podbielniak, Robertshaw-Fulton, Fischer & Porter, Foxboro—all in one day.

The Chem Show for any existing type of process equipment or service (and probably for some that you didn't know existed).

Working models

The trend in this year's show is toward exhibition of actual working models. Patterson-Kelley, for example, will feature a new combination unit capable of simultaneous blending and drying of a wide range of chemical formulations. Another display will be an operating installation of Pfaudler's new "Colloidaire Separator" for clarification of process waste liquids and recovery of materials in liquid suspension.

A "process workshop" (Speedline) will feature actual welding of process piping and fittings in the booth.

Chemicals and construction

The Exposition will not, of course, be strictly limited to processing equipment. Practically all of the major construction companies will be on hand with the low-down on new processes, new techniques, new methods of getting things done. Nor will chemicals and materials be neglected—most of the biggest producers are to be represented.

To get the most out of the Show—with the least effort—use the Guide which starts on page 127 of this copy of *CEP*. Here, in addition to booth numbers, you will find resumés of products to be exhibited, and, more important perhaps, names and titles of company engineers who will be present for discussion, consultation, and technical advice.

22 page complete listing of What to See and Where to Find It begins on page 127.

Your GUIDE to the EXPOSITION

NEW YORK COLISEUM NOV. 30 - DEC. 4, 1959

- Companies—alphabetically listed
- Exhibits, services and features
- Who to talk to

ACF Industries, Inc., W-K-M Div., Houston, Texas. 941

A.P.V. Co., Inc., Buffalo, N. Y. 1302

Abbe, Inc., Paul O., Little Falls, N. J. Grinding, mixing & drying machinery, steel ball mill, ribbon mixer, vacuum dryer.
O. H. Garlick, pres., R. E. Ringen, sls. mgr., H. B. Fuller, secy.; sls. engrs. 984

Adams Co., Inc., R. P., Buffalo, N. Y. 836

Aeroquip Corp., Jackson, Mich. 1255

Airetool Mfg. Co., Springfield, Ohio. Tube cleaning equipment, tube expanding equipment including pneumatic & electric tube expansion control systems. Pneumatic hand tools.
I. T. Thornson, sls. mgr., T. Brandon, mgr., N. Y.; H. A. Russell, mgr., Phila.; sls. engrs. 841

Airslide-Dry-Flo Car Div., General American Transportation Corp., Chicago, Ill. 435, 436, 442

Airsonic Industrial Stethoscopes, M. Paquet & Co., Inc., New York, N. Y. 1374

Alberene Stone, Div. of Georgia Marble Co., New York, N. Y.
Building & construction material, stone fume hoods, center, & well tables. 465

Aldrich Pump Co., Allentown, Pa.
4" Aldrich-Groff variable stroke pump, 100,000-PSI air pump.
R. H. McPeake, sls. mgr., J. B. Thomas, sls. engr.; L. W. Shelly, ch. engr.; J. C. Groff, dev. engr.; H. P. Meitzler, asst. ch. engr. 1108, 1110

Booths 9 to 238—1st floor
309 to 706—2nd floor
802 to 1099—3d floor
1100 to 1447—4th floor

Allied Chemical Corp., New York, N. Y. **Divisions: Barrett, International, General Chemical, National Aniline, Nitrogen, Plastics & Coal Chemicals, Semet-Solvay, Solvay Process.**
Polyurethane applications, fluorine chemistry, nitrogen products, hydrogen peroxide, uses of methylene chloride, Plaskon Nylon and alkyd molding compounds. 955, 957, 959, 961

Alite Div., United States Stoneware Co., Orrville, Ohio. 111

Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Material handling equipment, pumps, valves, grinding plants, controllers, dielectric heater. 636

Allis Co., The Louis, Milwaukee, Wis. 100

Alloy Products Corp., Waukesha, Wis. Stainless steel sanitary fittings & valves, stainless steel containers, deep-drawn parts, stampings.
W. J. Machowitz, Jr., v-p, sls.; A. A. Cole, ch. engr.; S. Piza, sls.; B. J. Johnson, rep. N. Y. 1205

Alloy Steel Casting Co., Southampton, Pa. 1076

Alloy Steel Div., Republic Steel Corp., Massilon, Ohio. 68

Alloy Steel Products Co., Linden, N. J. Corrosion resistant valves & nuclear valves.
R. E. Boller, Jr., gen. sls. mgr., H. V. Evans, Jr., dist. sls. mgr.; sls. engrs. 22

Alpine American Corp., Saxonville, Mass. 1432, 1434

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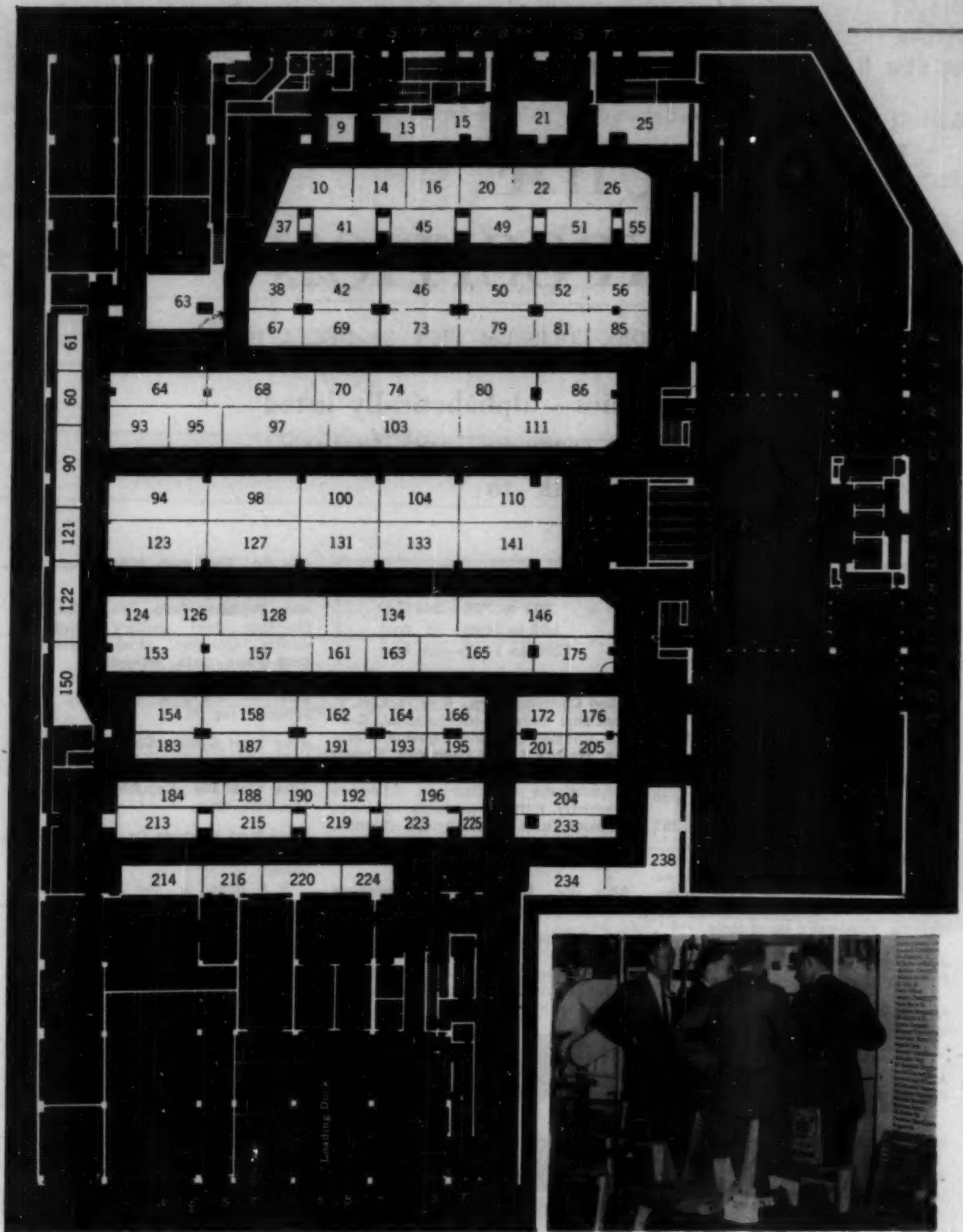
Main entrance to New York Coliseum, portal to Chem Show.



FIRST FLOOR: 27th Exposition of Chemical Industries
New York Coliseum Nov. 30-Dec. 4, 1959

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Alsop Engineering Corp., Milldale, Conn.
Sealed disc filters, PAK 12-20 large capacity filters, "S" type barriers, "Dehydravac," centrifugal pumps.
S. Alsop, pres.; R. F. Harland, gen. mgr.; J. F. Zoufaly, mgr. agitation div., A. Willen, mgr. filter div.; others. 381

Aluminum Co. of America, Pittsburgh, Pa. 559

American Air Filter Co., Inc., Louisville, Ky. 676

American Chemical Society, Washington, D. C. 406

American Chemical Society News Service, New York, N. Y. 410

American Electric Power Service Corp., New York, N. Y. 1126

American Gas Furnace Co., Elizabeth, N. J.
Burners, furnaces, & appliances for chem. industry, batch-type rotary calcining furnace Model 1-FB, new line of burners.
F. C. Schaefer, sls. mgr., F. Korzeb, asst. sls. mgr.; W. D. Hornbruch, sls. engr.; H. J. Kempf, tech. engr. 833

American Heat Reclaiming Corp., New York, N. Y. 1058, 1060

American Hydrotherm Corp., L. I. City, N.Y.
High temperature liquid heating & cooling systems.
P. L. Geiringer, pres.; B. S. Breitman, v-p, others. 1161

American Institute of Chemical Engineers, New York, N. Y.
Publications of the Institute, including Chemical Engineering Progress, A. I. Ch. E. Journal, Monograph & Symposium Series brochures, general Institute literature.
L. T. Dupree, asst. publisher, P. A. Jolcuvar, adv. mgr. 1219

American Instrument Co., Inc., Silver Spring, Md. 445

American Machine & Metals, Inc., E. Moline, Ill. (See DeBothezat Fans, Filtration Engineers, Filtration Fabrics, Niagara Filters, & Tolhurst Centrifugals.) 456, 506, 556

American Messer Corp., New York, N. Y. 1083

American Meter Co., Pump Div., Philadelphia, Pa.
Controlled capacity pumps, new additions to product line.
L. G. Alaman, sls. mgr.; R. J. Browne, gen. mgr. 150

American Optical Co., Buffalo, N. Y.
"AO Electro-Polarizer," a "Goldberg Process Refractometer," & stereoscopic microscopes, medical microscopes & microscope accessories.
B. Dezendorf, G. Tatoian. 1081

American Plant Equipment Co., Elizabeth, N. J. 1282, 1284

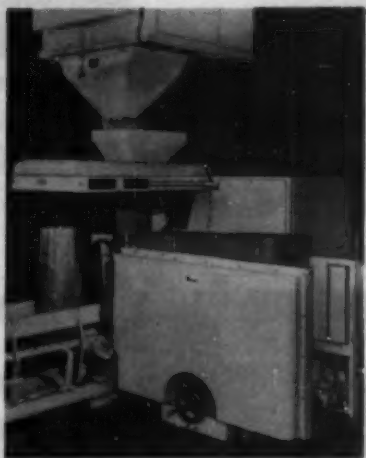
American Sterilizer Co., Erie, Pa.
Combination steam & gas sterilizer, laboratory sterilizer (square), "Spordex," bacterial spore strips, water still, & "Square-Pak" flasks (& closures).
E. D. Barry, mgr., E. R. Bindseil, prod. mgr.; S. M. Ellis, app. engr.; sls. reps. 366

American Tool & Machine Co., Boston, Mass.
Pictures & literature on new type equipment.
W. C. Crandall, N. Y. rep. 862

American Vulcathene Div., The Nalge Co., Inc., Rochester, N. Y. 1201

Amersil Quartz Div., Engelhard Industries, Inc., Hillside, N. J. 192, 196, 225

Ampco Metal, Inc., Milwaukee, Wis. 412



First fully operational automatic open-mouth multiwall bag feeder to be shown by Bemis Bro. Bag Co.

Analytical Chemistry, New York, N. Y., Washington, D. C. 410, 86

Analytical Measurements, Inc., Chatham, N. J. 314

Anderson, V. D., Co., Div. of International Basic Economy Corp., Cleveland, Ohio.
Oil & moisture expellers, air & steam traps, "Anderson Hi-eF" purifier.
M. J. Toth, sls. mgr., W. J. Gleason, Jr., mgr.; M. L. Waldron, sls. mgr.; W. H. Woods, engr. 1265

Andrews-Knapp Construction Co., Inc., L. I. City, N. Y. 175

Ansul Chemical Co., Marinette, Wis.
Major chemical groups, nitrogen heterocyclics, organic arsenicals, inorganic products & methylated products. Ansul dry chemical fire equipment.
W. R. Rinelli, mgr., chem. prod. div., F. W. Wedge, Jr., sls. mgr., chem. prod. div.; R. E. Thompson, tech. asst. to sls. mgr. & others. 95

Appareils Gachot, Enghien, France.
Valves & pumps for nuclear service, control instruments, & mass spectrometers. 1095

Armco Steel Corp., Middletown, Ohio. 1221, 1223

Armour Industrial Chemical, Chicago, Ill.
Aliphatic organic chemicals, antistalling agents for gasoline, & anticaking agents for hygroscopic materials.
L. M. Miller, mgr.; D. Bierman, Eastern mgr.; W. Ward, mgr.; sls. reps. 932, 934

Armstrong Machine Works, Three Rivers, Mich.
Glass model of the Armstrong inverted bucket steam trap, high pressure float traps, steam humidifiers, strainers.
T. H. Rea, gen. sls. & adv. mgr., T. M. Reed, sls. mgr.; O. E. Ulrich, factory rep. 1226

Armstrong Steam Trap Co., Three Rivers, Mich. 1226

Arrowhead & Puritas Waters, Inc., Glass Products Div., Los Angeles, Calif. 1085

Artisan Metal Products, Inc., Waltham, Mass.
Process equipment, wiped-filmed centrifugal evaporator, condensers, & evaporator-stripper. 874

Associated Cooperage Industries of America, Inc., St. Louis, Mo.
Tight & slack wooden barrels & kegs.
A. H. Knabb, ex. dir. 898

Autoclave Engineers Sales Corp., Erie, Pa. 346

Automatic Switch Co., Florham Park, N. J.
Solenoid operated valves, automatic transfer switches & electromagnetic controls.
W. F. Hurlburt, Jr., pres., R. F. McCormick, v-p., valves sls.; F. P. Spinelli, v-p, switch dept.; others. 847

Automotive Rubber Co., Inc., Detroit, Mich.
Rubber lining, materials & installation, cast iron, rubber lined, stainless steel & glass lined valves, Hypalon & Teflon diaphragm; control valves with air operator, gas & fume washing equipment.
R. L. Redmond, ex. v-p., W. J. Berin-

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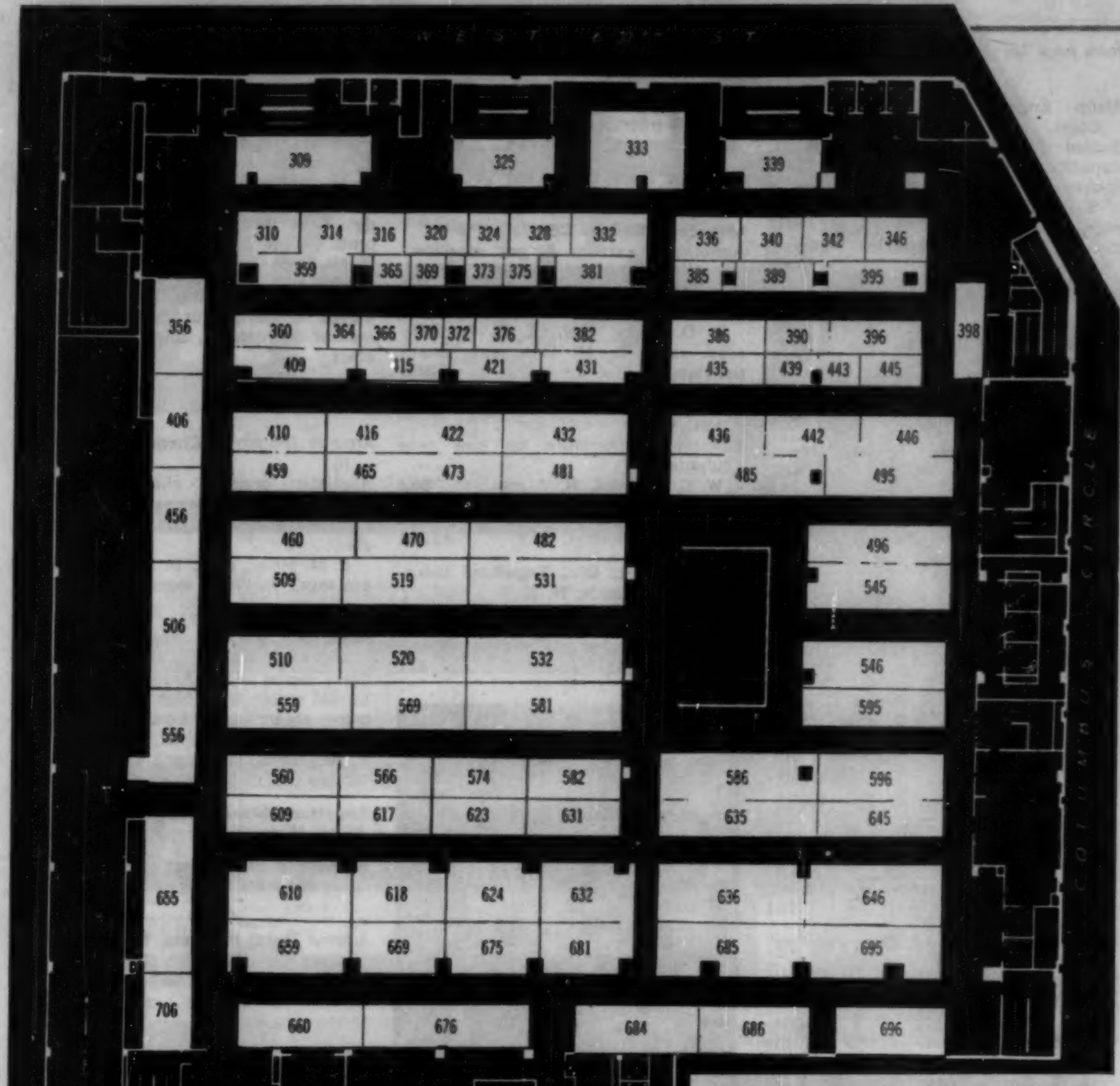

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ger., v-p., sls.; R. A. Noblett, mgr. valve dept.; R. R. Calaceto, mgr., proc. equip. div.; others. 802

B-I-F Industries, Inc., Omega Proportioneers Product Div., Providence, R.I. Process instrumentation and equip. for control of materials in motion. Plastic Dall flow tubes, positive displacement proportioning pump.
P. A. Coffman, A. Melnychuk, W. E. Milligan, J. F. Reidy, others. 660

Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa.
Seamless and welded pressure tubing and mechanical tubing in carbon, alloy, and stainless grades. "Lectrosonic" welded carbon tubing.
1002, 1004, 1006

Bailey Meter Co., Cleveland, Ohio.
Solid-state electric control components and systems for chem. process control.
C. H. Barnard, sls. mgr.; L. F. Richardson, sls. mgr.; E. B. Bossart, adv. mgr. 46

Baker Perkins, Inc., Saginaw, Mich.
Process equip. Multi-stage, push type centrifuge, high-output centrifuge, vertical mixers.
K. A. Mack, v-p; W. D. Chapman, asst. sls. mgr.; J. R. Powers, H. F. Geier, others. 560, 609

Baker Platinum Div., Engelhard Industries, Inc., Newark, N. J.
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Barber-Colman Co., Wheelco Instruments Div., Rockford, Ill. 395

Barco Mfg. Co., Barrington, Ill. 439

Barish Pump Co., New York, N. Y. 1074

Barneby-Cheney Co., Columbus, Ohio.
Actuated carbons, carbon wool.
H. L. Barneby, v-p; T. Barneby, sls. mgr.; N. Rowe, sls. engr.; R. Grener, sls. engr.; others. 52

Barnstead Still & Sterilizer Co., Boston, Mass.
Self-purifying recirculating systems, water stills, demineralizers, fine filters, purity meters.
D. G. Miller, sls. mgr.; D. C. Smith, tech. dir.; N. A. Everett, tech. svce. engr.; A. M. Fulton; others. 416

Bartlett & Snow Co., C.O., Cleveland, Ohio.
Experimental combination calciner and cooler, vibrating screens. 569

Beckley, Haltom & Hickman, New York, N. Y. 1342, 1363

Beckman Instruments, Inc., Fullerton, Calif.
Process equip., operating computer control system, stream, oxygen, infrared, & thermal conductivity analyzers.
R. E. Klees. 333

Bel-Art Products, Pequannock, N. J.
Plastic pumps, plastic drums, other plastic handling equipment.
K. Landsberger, pres.; G. McClure, chf. engr., R. E. Moser, West Coast rep.; C. M. Tacopina, sls. 889

Bemis Bro. Bag Co., Minneapolis, Minn.
Automatic open-mouth multiwall bag feeder, explosive bags, new bag styles and packaging material. 164, 166

Biach Industries, Inc., Cranford, N. J.
"Biach Bolt Tensioners," controlled bolt loading equipment.
J. L. Biach, pres.; F. H. Stillman, v-p; J. L. Biach, v-p. 1253

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Bird Machine Co., So. Walpole, Mass.
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Bishop & Co., Platinum Works, J., Malvern, Pa.
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Blackmer Pump Co., Grand Rapids, Mich.
Variable volume pumps, proportioning units, standard positive-displacement rotary vane-type pumps.
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Blickman, S., Inc., Weehawken, N. J.
Lab. furniture & casework, SS safety enclosures, SS process equip.

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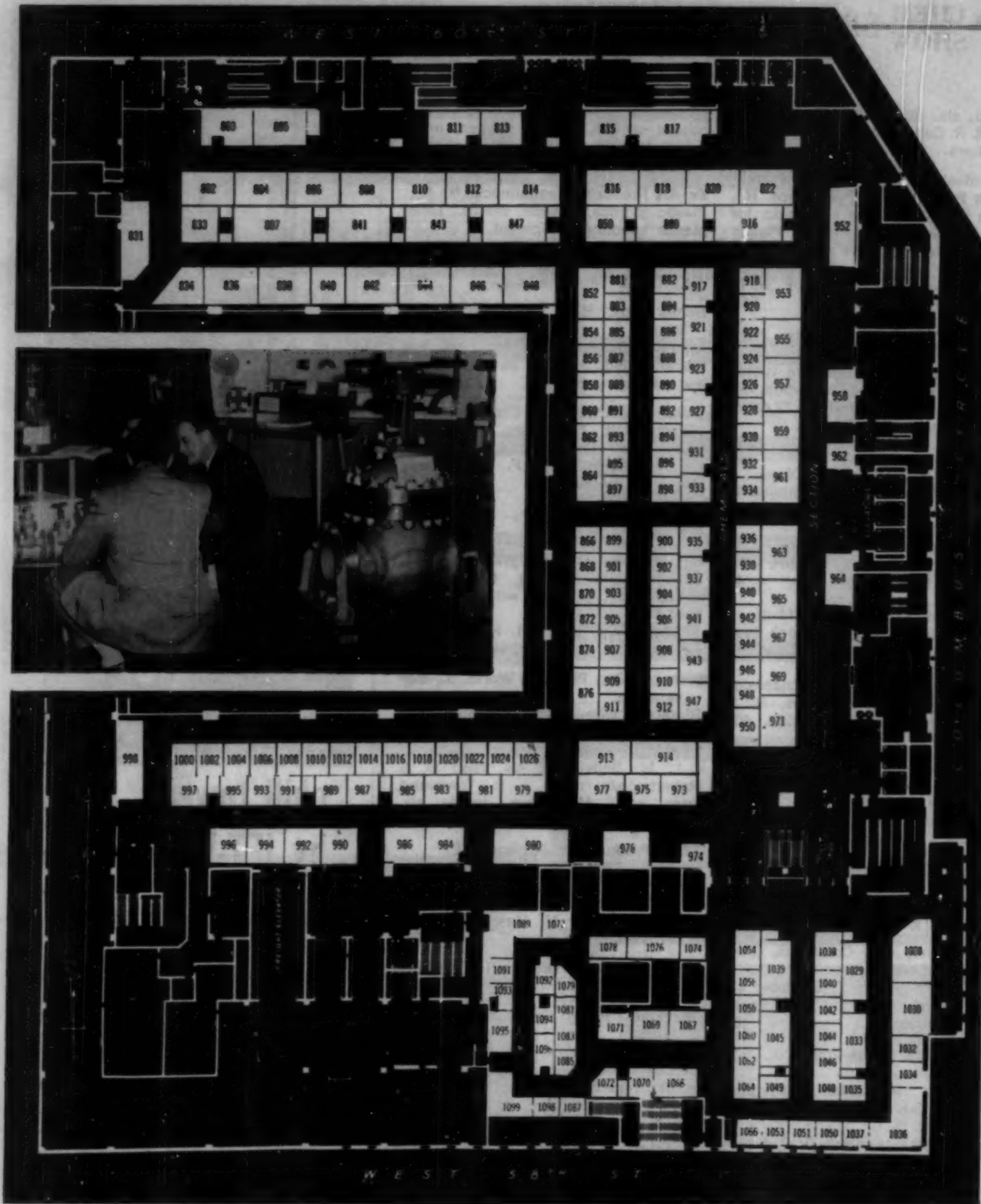

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Bowen Engineering, Inc., North Branch, N. J.
Spray drying installations and processes.
R. T. Reeve, pres.; D. A. Smith, v-p; D. W. Belcher, v-p, eng.; J. J. Quinn, sls. mgr., others. 706

Bowser, Inc., Potter-Bowser Div., & Process Filters Div., Ft. Wayne, Ind. 396, 1115

Brabender Corp., Rochelle Park, N. J. 37

Brabender Instruments, C. W., Inc., South Hackensack, N. J.
"Plastograph" & attachments, Viscosimeters, and moisture testing equip.
W. T. Blake, v-p. & gen. mgr. 340

Bradley Washfountain Co., Milwaukee, Wis. 1128, 1130

Bragar Co., Inc., Norman, Newark, N.J.
Pyrometric temp. & saturable reactor controls, scanning systems, annunciator alarm systems, high pressure thermocouple & sealing glands, spec. thermocouple assemblies.
N. H. Bragar, G. T. Reed, A. D. Kirby, M. Dalis, others. 1230, 1232

Bramley Machinery Corp., Edgewater, N. J. 187

Brinkmann Instruments Inc., Great Neck, N. Y.
Analytical and recording instruments.
C. A. Brinkmann, pres., H. Apt, K. P. Brinkmann, W. Reinhardt, others. 360

Brookfield Engineering Laboratories, Inc., Stoughton, Mass.
Viscosity-measuring equip.
W. B. Brookfield, pres., sls. mgr.; D. W. Brookfield, dir. of res.; R. A. Minard, tech. sls. mgr.; H. W. Curtis, chf. eng. 885, 887

Brooks Rotameter Co., Lansdale, Pa.
Rotameter flow measurement instruments & accessories featuring MPT interchangeable electric & pneumatic flow transmitters, totalizers, & flow alarms.
D. N. Brooks, pres.; N. S. Brooks, v.p., mfg.; J. T. Aldrich, Jr., asst. sls. mgr.; S. Blechman, ex. v.p., sls.; others. 998

Brown Co., Boston, Mass. 923

Brown, Judson G., Wakefield, Mass.
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Bryant Mfg Co., Indianapolis, Ind. 1089

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Buell Engineering Co., Inc., New York, N. Y. 1204

Buffalo Meter Co., Inc., Buffalo, N. Y.
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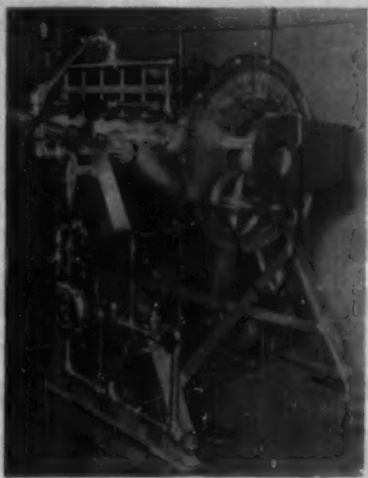
Industrial wire cloth, bolting wire cloth, filter wire cloth, vibrator & shaker screens.
C. F. Scheeler, Jr., pres.; N. F. Grundner, sls. mgr. 1381

Buflovak Equipment Div., Blaw-Knox, Buffalo, N. Y. 581



Rotary batch-type furnace, No. 1-FB, will be displayed by American Gas Furnace Co.

Burling Instrument Co., Chatham, N. J.
Differential expansion type temp. controllers, thermostats, alarms, & safety temp. limit switches.
H. S. Burling, pres.; S. Burling, sls. mgr.; R. Ford, sls. engr. 9

Buschman Products Inc., New York, N. Y.
New models of the "Jet-Mogenizer" with increased capacity.
N. H. Buschman, pres., H. Horn, R. R. Marshall, T. F. Mallon. 1198

Byers Co., A. M., Pittsburgh, Pa. 1051

California Pellet Mill Co., Crawfordsville, Ind. 1360

Cambridge Instrument Co., New York, N. Y.
Precision electrical and mechanical measuring instruments.
W. H. Jefferson, v.p.; C. T. Kruse, secy.; A. T. Frieling; B. O. Watkins; others 376

Cameron Iron Works, Houston Texas.
Valves and pressure gauges.
R. Zorn, dist. sls. mgr.; B. Wanger, sls. engr. 1062

Carbone Corp., Boonton, N. J.
"Polybloc" impervious graphite heat exchanger, "Graphiton" rupture discs, cascade coolers, "Polybloc" pump units.
E. B. Eaton, Jr., pres.; E. G. Dixon, sls. mgr.; M. J. Winson, mgr.; R L. Seidler, mgr.; others. 803

Carey Mfg. Co., Philip, Cincinnati, Ohio 1152

Carlisle Gas Burner Corp., Millville, N. J. 1251

Carpenter Steel Co., Union, N. J. 675

Carrier Conveyor Corp., Louisville, Ky.
Vibrating heat trf. equip. featuring mechanical "Amplitrol" feeder, vibrating coolers, dryers, and heaters.
R. M. Carrier, Jr., pres.; J. M. Moris, v.p.; A. G. Westerman, v.p.; A. Musschoot, v.p.; others. 127

Carver, Inc., Fred S., Summit, N. J. 90

Catalytic Combustion Corp., Detroit, Mich.
Metallic supported catalysts, catalytic fume combustion systems and catalytic pressure reactors.
R. J. Ruff, pres.; P. H. Goodell, v.p., sls.; J. L. Donahue, mgr. 1209

Centrico, Inc., Englewood, N. J.
New centrifugal separators featuring "Westfalia" model SAMN-15007 automatic desludger.
J. Spiekermann, gen. mgr.; W. Wendenburg, sls. mgr.; C. Maass, sls. prom. mgr.; P. Stahl, ch. engr.; others 842

Centrifix Corp., Cleveland, Ohio. 1180

Chain Belt Co., Milwaukee, Wis. 1416

Chem Flow Corp., Lodi, N. J.
All-glass filter assemblies, automatic reflux splitter, glass relief valve.
E. J. Mooney, pres.; H. Schilling, gen. mgr.; G. F. Koepplinger, sls. mgr.; J. Purcell, others. 1227

Chemical Construction Corp., New York, N. Y.
Flow chart of ammonia processes and working model of Chemico Venturi-type gas plexiglass scrubber. 952

Chemical Engineering, New York, N. Y. 432, 481

Chemical Engineering Catalog, New York, N. Y. 86

Chemical and Engineering News, Washington, D. C., and New York, N. Y. 410, 86

Chemical Engineering Progress, New York, N. Y.

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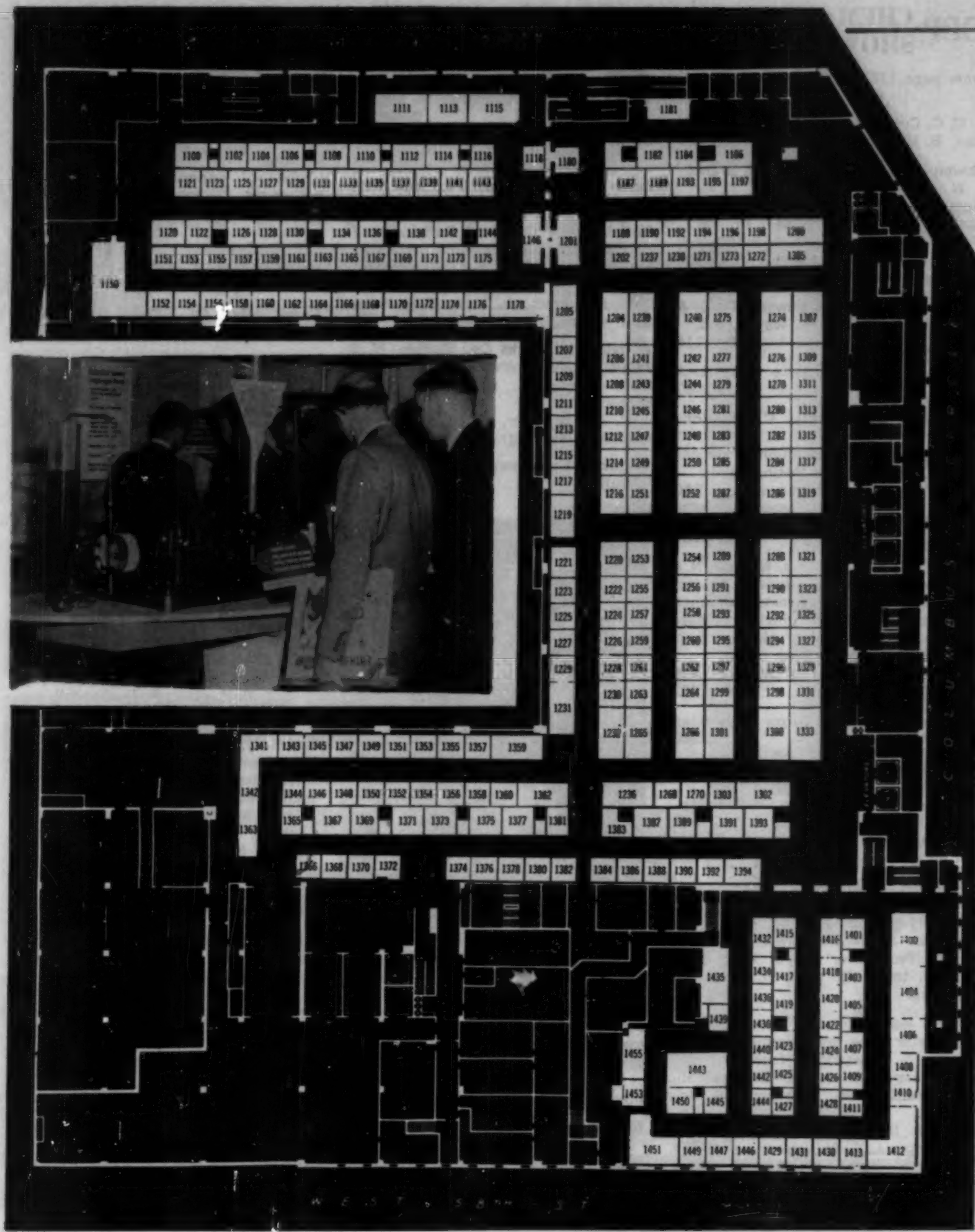

FOURTH FLOOR: 27th Exposition of Chemical Industries
New York Coliseum Nov. 30-Dec. 4, 1959

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See: American Institute of Chemical Engineers listing. 1219

Chemical Materials Catalog, New York, York, N. Y. 86

Chemical & Pharmaceutical Industry Co., Inc., New York, N. Y.
Packing and filling machines; Lab. equip. featuring three-dimensional shaping machine.
P. R. Portje, pres. 1064

Chemical Plants Div., Blaw-Knox Co., Pittsburgh, Pa.
See: Blaw-Knox Co. listing 581

Chemical Processing, Chicago, Ill. 880

Chemical Week, New York, N. Y. 432, 481

Chemicolloid Laboratories, Inc., Garden City Park, N. Y.
Industrial and sanitary colloid mills.
D. F. O'Keefe, pres.; L. E. Futman, v.p.; W. R. O'Keefe, v.p.; W. A. Behrens, res. & eng. dir. 618

Chemineer, Inc., Dayton, Ohio.
Fluid agitation equip., new "Modulflex" turbine agitator and "Chemineer" portable agitators.
R. Shaffer, pres.; R. Bates, tech. dir.; E. V. Goodwiller, ch. des. engr.; P. L. Fondy, ch. app. engr. 1220

Chemiquip Co., New York, N. Y. 888

Chemo-Puro Mfg. Corp., Newark, N. J.
Fungicides and intermediate chemicals.
P. C. Hereld, ex. v.p.; J. F. Hogan, Mgr. 962

Chemplast, Inc., Newark, N. J. 1092

Chempump Div., Fostoria Corp., Huntington Valley, Pa. 659

Cherry-Burrell Corp., Cedar Rapids, Iowa. 1039, 1045, 1049

Chicago Bridge & Iron Co., Chicago, Ill. 844

Chiksan, Co., Brea, Calif. 1268, 1270

Clark-Cooper Co., Palmyra, N. J.
Metering Pumps, plunger & diaphragm types.
R. A. Taylor, pres.; J. F. Haskett, sls. mgr. 1343, 1345, 1347, 1349

Cleveland Mixer Co., Bedford Heights, Cleveland, Ohio. 1067, 1069

Cleveland Vibrator Co., Cleveland, Ohio.
Air and electric vibrators, air powered vibratory feeders.
J. Becker, H. McCoy, R. Stahura, L. Juergens, others. 993, 995

Cleveland Worm & Gear Co., Cleveland, Ohio.
Worm and gear drive components, speed variator integrals with motor, centralized lubrication system.
L. O. Witzenburg, v.p., sls.; R. E. Dittoe, sls. mgr.; H. H. Platek, adv. mgr.; E. J. Gesdorf, sen. app. engr. 158

Cobalt Information Center, Columbus, Ohio. 1415

Coleman Instruments, Inc., Maywood, Ill. 320

Colonial Plastics Mfg. Co., Industrial Div., Cleveland, Ohio.
Polyvinyl chloride items; pipes, molded fittings for all pipes, valves.
W. Hatfield, v.p., gen. mgr.; C. R. Owen, sls. mgr.; J. E. Voelker, asst. sls. mgr.; R. E. Sharpless, Jr., Eastern dist. sls. mgr. 1283

Colton Co., Arthur, Div. of Snyder Corp., Detroit, Mich.
Drug, chemical, and filling machy., featuring new variable speed drive coating stand with pan, hard capsule banding machine, single rotary press.
K. B. Hollidge, ex. v.p.; W. A. Doepel, sls. mgr.; A. R. Pearce, dir. customer service; L. P. Gajda, v.p., engr. 50

Combustion Engineering, Inc., Raymond Div., Chicago, Ill.
Working models of fluid bed dryer and flash dryer, vertical mill in SS and nickel, model mechanical air separator.
A. J. Chubb, sls. mgr.; R. D. Nickerson, sls. mgr.; E. J. Karges & C. A. Leet, prod. mgrs., sls. engrs. 646

Commercial Filters Corp., Melrose, Mass. 223

Conax Corp., Buffalo, N. Y. 1230, 1232

Conneaut Rubber & Plastics Co., Conneaut, Ohio. 111

Consolidated Vacuum Corp., Rochester, N. Y.
High-vacuum distillation equip., high vacuum stills and centrifugal molecular stills.
M. Garber, dir. market.; R. Brosman, mgr.; H. Waldeck, mgr.; W. Cameron, mgr.; others. 1353

Continental Can Co., Inc., New York, N. Y. 899, 901, 903

Continental-Emsco Co., Los Angeles, Calif. 868

Continental Mfg. Co., Cincinnati, Ohio.
"Tufline" plug valves, jacketed valves, screwed cover plug valves, hydraulic or pneumatic actuators.
C. L. Reed, Jr., pres.; F. A. Godley, Jr., v.p.; R. Smith, ch. engr.; D. S. Sinkler, sls. engr. 876

Continental Oil Co., Petrochemical Dept., New York, N. Y. 930

Cooper Alloy Corp., Hillside, N. J. 103

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Corley Co., Inc., Boonton, N. J.
Fractional horse power "canned" magnetically-driven pumps.
R. N. Corley, pres. 1116

Cornell Machine Co., New York, N. Y. 1212

Corning Glass Works, Corning, N. Y.
Lab. Sales Dept.; Teflon stopcock & metal-shielded, graduated cylinder. Plant Equip. Sales Dept.; glass pipe, shell & tube heat exchangers, fractionating columns, new low-cost drainline.
J. D. Pisula, sls. mgr.; W. H. Tomb, Jr., mgr.; D. R. Briggs, E. K. Lofberg, others. 134

Coulter Industrial Sales Co., Elmhurst, Ill. 1444

Crane Co., Chicago, Ill.
Brass, iron, steel, and alloy valves & special application products.
G. F. Burley, v.p. sls.; C. H. Lovelace, gen. mgr.; J. E. Bradbury, mgr.; R. W. Lindsay, dir. sls. 422

Crane Packing Co., Morton Grove, Ill.
Metallic and fabric packings, mechanical seals.
F. G. Hudson, Jr., adv. mgr.; J. R. Morton, off. mgr.; W. D. Gordon, A. Jaeger, others. 908

Crawford Fitting Co., Cleveland, Ohio.
"Swagelok" tube fittings in variety of machinable metals and plastics.
F. A. Lennon, pres.; D. P. Haag, sls. mgr.; J. P. McCready, asst. sls. mgr.; F. J. Callahan, Jr., res. engr. 987, 989

Crawford & Russell, Inc., Stamford, Conn.
Design & construction—chemical process plants.
S. T. Russell, pres.; J. R. Crawford, v.p.; S. A. Fruchtman, ch. des. engr.; L. Basel, ch. proc. engr. 1000

Croll-Reynolds Co., Inc., Westfield, N.J. 1054

Croll-Reynolds Engineering Co., Inc., New York, N. Y.
"ClaRite" filtration equip., operating pilot scale unit; "FlexoDisc" expansion joints.
R. S. Croll, pres.; J. J. Quinlan, v.p.; W. A. Korb, mech. engr.; L. O'Hanlon, engr. 1054

Crossley Machine Co., Trenton, N. J. 1423, 1425

Crucible Steel Co. of America, Titanium Div., Pittsburgh, Pa. 1424, 1426, 1428

Curtiss-Wright Corp., Metals Processing Div., Buffalo, N. Y. 1344, 1346

Daffin Manufacturing Co., Lancaster, Pa.
Air and dust control systems, pellet & hammer mills, mixers & blenders.
Daffin, Watts, Coho, Dodd. 1400, 1404

Davenport Machine and Foundry Co., Davenport, Iowa. 818

Day Co., Minneapolis, Minn.
Bulk handling & storing equipment, & dust control equipment & systems.
R. E. Gorgen, ex. v.p.; A. E. Swanson, v.p.; E. W. Anderson, v.p.; R. H. Jensen, sls. 45

J. H. Day Co., Div. of Cleveland Automatic Machine Co., Cincinnati, Ohio.
Mixing, blending, sifting, milling equipment, featuring new high speed liquid and vertical dispersion mixers.
M. Miller, v.p., gen. mgr.; G. Miller, adv.; sls. engrs.; des. engrs. 121, 122

Dean Brothers Pumps, Inc., Indianapolis, Ind.
New chemical "pH" pump, available in 14 alloys. N. Dean, Jr.; pres., J. Dean, v.p. & sec.; A. J. Herrman, Jr., v.p., eng.; R. C. Bierck, v.p., sls. 1245, 1247, 1249

Dean Panel Coil, Div. Dean Products, Inc., Brooklyn, N. Y.
Fittings for improved flow and capacity, gauges.
R. Raskin, sls. mgr.; W. Raskin, gen. mgr.; M. W. Ehrlich, chief engr. 184

DeBothezat Fans Div., American Machine & Metals, East Moline, Ill.
Bifurcator ventilating fans.
R. M. Hammes, gen. sls. mgr., R. W. Bouslough, sls. mgr., B. A. Buss, dir. eng., & others. 556

Dekoron Products Div. Samuel Moore & Co., Mantua, Ohio. 1182, 1184

De Laval Separator Co., Poughkeepsie, N. Y.
Separating and clarifying equip., 5,000 gal./hr. hermetic centrifuge, P-141 SS heat exchanger, "Gyro-Tester" high-speed centrifuge.
G. F. Wheelright, Jr., ind. sls. mgr.; W. C. Porch, N. Y. sls. mgr.; D. A. Gardner, Chicago sls. mgr.; D. M. Landis, Pacific sls. mgr. 94

Delavan Mfg. Co., Des Moines, Iowa.
Nozzles for spray washing, drying, metal cleaning, chem. processing.
R. E. Keene, adv. & sls. mgr. 1354, 1356

Delaware Barrel & Drum Co., Wilmington, Del.
Polyethylene drums and tanks. 1187, 1189, 1193

Denver Equipment Co., Denver, Col. 1146

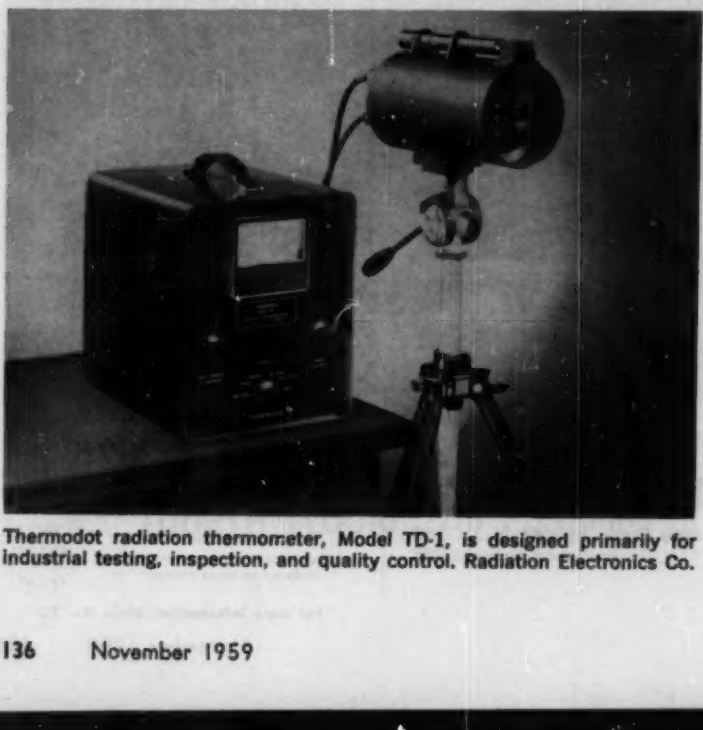
Derrick Mfg. Co., Buffalo, N. Y. 811

Devine Mfg. Co., J. P., Pittsburgh, Pa.
Equipment for process industries, vacuum double drum dryer and conical blender.
A. M. Cox, pres.; G. R. Cox, v.p.; E. J. Cox, treas.; R. Brockett, sls. mgr.; others. 1372

DeZurik Corporation, Sartell, Minn. 907

Dicalite Dept., Mining & Mineral Prod. Div. Great Lakes Carbon, Corp., Los Angeles, Calif. 204

Distillation Eng. Co., Livingston, N. J.
Distillation equipment, columns, automatic reflux controllers, redistributors, etc.
P. N. Heere, pres.; T. Baer, prod. eng.; C. L. Safford, Jr., sls. eng.; L. Blackman, prod. eng. 1048



Thermodot radiation thermometer, Model TD-1, is designed primarily for industrial testing, inspection, and quality control. Radiation Electronics Co.

Dore Company, John L., Houston, Tex.
Teflon products, gaskets, fittings, expansion joints, bar stock shapes, piston rings, rod packings.
J. L. Dore, pres.; J. S. Bawcom, v.p.; H. I. Thompson, Jr., sls. mgr.; S. D. Glaser, sls. eng.; others. 1295, 1297

Dorr-Oliver Inc., Stamford, Conn.
Process equip., FluoSolids drying system, centrifuges, centrifugal pumps.
J. D. Hitch, Jr., pres.; L. R. Boling, ex. v.p.; mgrs. of divisions. 531

Downingtown Iron Works, Div. Pressed Steel Tank Co., Downingtown, Pa. 631

Dracco Div. of Fuller Co., Cleveland, Ohio.
Airstream conveyors and dust control equip., glass-bag filter and accessories for automatic handling.
G. Afl Gieseler, pres.; H. W. Gaeckle, v.p.; G. Schneider, v.p.; sls. mgrs. & sls. engrs. 495

Drayer Hanson Div., National-U.S. Radiator Corp., Los Angeles, Calif. 850

Ducon Co., Inc., Mineola, N. Y. 990, 992

Duralab Equipment Corp., Brooklyn, N. Y.
Scientific lab. furniture and equip., distillation rack, benches, sinks.
D. Kayne, adv. mgr. 359

Durametallic Corp., Kalamazoo, Mich.
Sealing products for chem. proc. equip., "Dura" circulating seals, flexible metallic packings, oil pressure systems.
F. M. Smith, asst. sls. mgr.; J. L. McQuillen, mgr.; J. P. Moens, J. H. Cronin, & others. 1216

Duriron Co., Inc., Dayton, Ohio. 520, 532

Dustex Corp., Buffalo, N. Y.
Dust collector equip., Dustex D-584, Dustex Microclone, Dustex MM400, Dustex Roto-Jet, Dustex Economy Collector, Dustex Vacuum Valve.
H. O. Hazel, pres.; R. S. Brookman, v.p.; L. D. Morris, ch. engr.; W. F. Gibby, res. dev. hd. 1299, 1301

du Verre, Inc., Buffalo, N. Y.
Reinforced plastic chem. plant equip.
T. F. Killeen, v.p., sls.; R. H. Gilmore, ch. sls. engr.; H. Hasbrouck, gen. mgr.; J. Corcoran, N. Y. rep. 891

Eagle-Picher Co., Cincinnati, Ohio.
Industrial & commercial insulations, cement blocks, pipe covering, felts, protective coatings, catalyst supports filter aids, absorbents, mineral fillers for paints, polishes, paper and fertilizer.
R. L. Bockstahler, A. H. Boylan, Jr., admin. asst. 1167, 1169

Eastern Industries Inc., Hamden, Conn. 1275

Eastman Kodak Co., Rochester, N. Y. 838

Eaton-Dikeman Co., Mount Holly Springs, Pa.
Filters and industrial filter paper.
T. H. Logan, Jr., sls. mgr.; E. E. Avery, Jr., sls. engr.; L. R. Vianey, tech. dir.; C. U. Stevens, res. assoc. 1120

Eclipse Fuel Eng. Co., Rockford, Ill.
Heat process equip., horizontal vaporizer, flowmeters, flowmeter switches.
E. E. Magnuson, div. mgr.; J. K. Baker, sls. mgr.; M. Benson, sls. engr.; A. D. Wilcox, div. mgr.; others. 973

Eco Engineering Co., Newark, N. J.
Small chemical process pumps and equipment, featuring air motor driven assemblies, explosion proof dispensing valve.
J. Eisenberg, sls. mgr.; E. Anderson, ch. eng.; L. Stone, ch. eng.; R. Ostarnder, ch. eng. 978

Edison Industries, Thomas A., Instrument Div. McGraw-Edison Co., W. Orange, N. J.
"Omniguard" continuous monitoring system.
V. W. Rose, adv. mgr.; R. P. Zupa, asst. sls. mgr.; G. V. Boselli, ind. sls. super.; J. P. Zercoe, sls. engr.; R. R. Schramm, engr. 945

Eiche & Associates, Inc., New York, N. Y. 868, 1236

Eimco Corp., Salt Lake City, Utah.
Material handling equip., "Rotobelt" and Flotator-clarifier.
R. Richter, v.p.; D. Dahlstrom, dir. res. dev.; F. T. Weems, dist. mgr.; T. A. Edwards, dist. mgr.; others. 80, 81

Electric Hotpack Co., Inc., Philadelphia, Pa.
Electric bench furnace, safety oven, controlled temp. & humidity chamber, temp. bath, portable controlled environmental room.
W. T. White, dir. sls.; W. L. Rariden, adv. mgr.; A. S. Mann, v.p. 373, 375

Electrode Div. Great Lakes Carbon Corp., New York, N. Y. 204

Engelhard Chemical Div. Engelhard Industries, Inc., Newark, N. J. 192, 196, 225

Entoleter Div. of Safety Industries, Inc., New Haven, Conn. 645

Eriez Mfg. Co., Erie, Pa.
Complete line of permanent non-electric magnetic separation equip. featuring "Hi-Vi" vibratory feeders.
R. F. Merwin, pres.; M. L. Cramer, sls. mgr.; N. Hirt, adv. & sls. mgr.; R. W. Shively, mgr.; sls. reps. 909, 911

Ertel Eng. Corp., Kingston, N. Y.
Liquid handling equip., filters, filling machines, pumps, steam-jacketed kettles, mixing and storage tanks, new gravity filler.
F. J. K. Ertel, pres.; G. P. Vogel, gen. sls. mgr.; J. F. Schomer, res. dir.; O. A. Mockridge, sls. mgr. 623

Ethylene Chemical Corp., Summit, N. J. 971

Ever-Tite Coupling Co., New York, N. Y.
Quick couplings for product transfer.
J. T. Krapp, pres.; G. F. Mullins, v.p.; J. A. Buchanan, sls. mgr.; B. A. Freiwald, adv. dir. 1159

Exact Weight Scale Co., Columbus, Ohio. 21

Fairbanks, Morse & Co., Chicago, Ill. 1323, 1325, 1327

Falcon Alarm Co., Summit, N. J.
Tank overfill alarms.
C. E. G. Reeves, pres.; C. P. Sager, v.p. 1343, 1345, 1347, 1349

Falls Industries, Inc., Solon, Ohio.
"Impervite" processing equip., graphite components.
R. J. Zook, pres., gen. mgr.; J. Reys, v.p. 131

Fansteel Metallurgical Corp., North Chicago, Ill.
Acidproof equip., bayonet heaters, heating & cooling coils, condensers in tantalum, titanium, zirconium, heater tubes, submersible pump.
R. W. Rawson, mgr.; J. W. Rose, sls. mgr.; J. Chelius, mgr.; engrs. 617

Farval Corp., Cleveland, Ohio. 158

Fenwal Inc., Ashland, Mass. 890, 892

Ferranti Electric, Inc., Hempstead, N. Y.
Transformers, instruments, electronic equip., featuring cone-plate viscometer.
D. G. Pacy, mgr. prod. sls. 1144

Fibercast Co., Sand Springs, Okla.
Epoxy resin glass reinforced pipe and fittings.
J. Hutchison, sls. mgr.; J. W. Bush, sls. rep.; J. Hutchison, sls. rep. 870

Fike Metal Products Corp., Blue Springs, Mo. 1427

Filterite Corp., Timonium, Md.
Filtration equip., diamond filter tubes, filter housings, multitube filter, plastic housing for multitube filters.
J. B. Masaschi, tech. dir.; R. W. Miller, Jr., v.p.; C. A. Miller, Jr., sls. mgr. 1303

Filtration Engineers Div., American Machine & Metals, Inc., East Moline, Ill.
Rotary type vacuum type filters of string discharge, scraper discharge, pre-coat and roller discharge types, horizontal rotary vacuum filter.
R. M. Hammes, gen. sls. mgr.; L. Jauhola, sls. mgr.; S. Ehlers, sls. mgr.; J. Stauffer, sls. & others. 456

Filtration Fabrics Div., American Machine & Metals, Inc., East Moline, Ill.
"Feon" filtration fabrics of all types.
R. M. Hammes, gen. sls. mgr.; B. A. Buss, dir. eng.; C. T. & W. A. White, sls. reps., West Coast; others. 556

Filtros Inc., East Rochester, N. Y.
Porous ceramics, liquid and air filtration equip., materials and methods of filtration.
R. G. McDonald, pres.; R. L. Ellis, sls. mgr.; H. J. Robillard, mgr. tech. sls. 854, 856

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Fischbein Co., Dave, Minneapolis, Minn.
Filled bag closing equipment.
H. Fischbein, G. Fischbein. 872

Fischer & Porter Co., Hatboro, Pa.
Chlorinators & chem. feed equip., electronic and pneumatic instrumentation.
E. Kaltenhauser. 496

Fitzpatco Corp., Div. of W. J. Fitzpatrick Co., Chicago, Ill. 64

Fitzpatrick, W. J., Co., Chicago, Ill.
Grinding, tabletting, homogenizing equip.
R. Sofield, R. S. Cochran, W. E. Covey, G. W. Covey, others. 64

Flanders Filters, Inc., Riverhead, N. Y.
Air filtration equipment, featuring "Supply Air Purification Unit" and absolute type air filters.
J. V. Moore, sls. mgr. 937

Fletcher Div., The Sharples Corp., Philadelphia, Pa.
Batch type manual and semi-automatic and automatic centrifuges.
E. T. Taws, pres.; F. S. Claghorn, v.p.; H. B. Allison, dir. eng.; B. Entwisle, sls. engr. 459

Florida Development Commission, Tallahassee, Fla.
Advantages of Florida industrial location to the chemical industry.
K. R. Allen, ind. spec. 1037, 1050

Flow-Actuated Control Co., Englewood, N. J.
Pump and flow controls.
A. N. Reichel, pres.
1343, 1345, 1347, 1349

Flowline Corp., New Castle, Pa.
Corrosion-resistant "Flowline" welding fittings in SS, aluminum, and Inco alloy.
R. S. Brown, Jr., asst. sls. mgr. 805

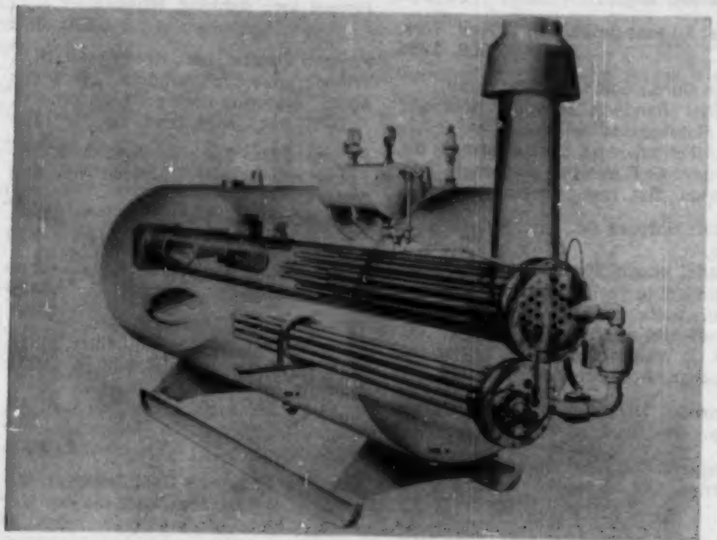
Fluid Energy Processing & Equipment Co., Philadelphia, Pa.
"Jet-O-Mizer" fluid energy mills.
N. N. Stephanoff, pres.; F. E. Albus, v.p.; J. P. McKenna, mgr.; J. Emlen, asst. mgr. 813

Food Machinery & Chem. Corp., Peerless Pump Div., Los Angeles, Calif.
Chem. process pumps, interchangeable.
S. M. Riordan, Jr., adv. mgr. 831

Food Processing, Chicago, Ill. 880

Foxboro Co., Foxboro, Mass.
Recording, controlling, indicating instruments for temp., pressure, humidity, & flow.
W. I. Strauss, mgr.; V. V. Tivy, ch. app. engr.; E. N. Hayes, mgr. oil & gas div.; G. I. Bilyeu, prod. sls. engr. 519

Freezing Equipment Sales Inc., York, Pa. 446



A model of Patterson-Kelley's new "Scalefree" indirect gas fired storage water heater will be on display at the company's booth.

Frick Co., Waynesboro, Pa.
Refrigerating, air conditioning, ice making & low-temperature equip.
W. H. Aubrey, v.p., asst. gen. mgr.; J. T. Sanders, asst. sls. mgr.; M. B. Watts, sls. prom. mgr.; all branch mgrs. 1258, 1260

Fuller Co., Catasaqua, Pa.
New "packaged" feeder & blower combination.
C. C. Kaesemeyer, gen. sls. mgr.; D. S. Douglass, asst. gen. sls. mgr.; R. F. Miller, mgr. advrt. & pub.; H. S. Sayre, mgr., gen. conveying div. 446

Fulton Sylphon Div. Robertshaw-Fulton Controls Co., Knoxville, Tenn. 1293

Gabb Special Products, Inc., Windsor Locks, Conn.
Industrial chemical mixer.
D. H. Thomson, pres.; R. E. Giague, v.p., plnt. mgr.; N. F. Smith, v.p., sls. mgr. 1106

Galigher Co., Salt Lake City, Utah.
Acid-proof sump pump, delta & squeeze valves, "Agitair" flotation machine.
J. T. Potts, pres.; H. E. Wright, ex. v.p.; S. L. Evans, gen. mgr.; M. L. Sayers, v.p. 843

Garlock Packing Co., Palmyra, N. Y.
Packings, Teflon gaskets and seals, corrosive-resistant materials.
A. E. Munch, dist. mgr.; T. L. Denney, gen. sls. mgr.; R. A. Lyons, mgr., adv. sls. prom. 415

Gems Co., Farmington, Conn.
Flow switches, level controls, position indicators.
E. H. Moore, part.
1343, 1345, 1347, 1349

General Alloys Co., Boston, Mass.
Nickel-chrome and chrome-nickel SS castings and fabrications for industrial use.
T. E. Franks, v.p., & sls. mgr.; J. S. Wooters, v.p.; A. S. Crawford, asst. sls. mgr. 193

General American Transportation Corp., Chicago, Ill.
Mixers, dryers, agitation equip., glass Turbo-mixer, Louisville fluidized bed dryer.
W. J. Stebler, pres.; R. G. Biesel, v.p.; S. D. Moseley, asst. to pres.; sls. engrs. & reps.
435, 436, 442, 446, 495

General Ceramics Co., Div. of Indiana General Corp., Keasbey, N. J.
Chemical process equip., LV series all-alumina ceramic pumps, VC series vacuum pumps.
C. E. Edwards, sls. mgr.; C. A. Brooks, sls. engr.; R. Karesh, sls. engr. 131

General Dispersions, Inc., Paterson, N. J. 967

General Electric Co., Apparatus Sales Div., Schenectady, N. Y. 482

General Laboratory Supply Co., Paterson, N. J.
Lab. apparatus featuring stirrers, polyethylene stopcocks for burets, chromatographic columns, funnels.
A. Samuelson, sls.; J. Rapp, sls.; I. Klein, pres.; R. Brooks, sls. 310

General Plastics Corp., Paterson, N. J.
Products & services designed for solving corrosion, buildup and sticking, high temp. and permanent lubricating problems in chemical industry.
R. Goldsmith, E. W. Davidson, R. Goetz, J. Simon. 967

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Gifford-Wood Co., Hudson, N. Y.
Wet mixing and homogenizing equip., material handling equip., colloid mills, mixers, flush type valves.
O. A. Johnson, pres.; A. E. Wilson, treas.; W. G. Engler, v.p. & sls. mgr.; sls. engrs. 219

Glascote Products, Inc., subsidiary of A. O. Smith Corp., Cleveland, Ohio. 596

Glengarry Processes, Inc., Bay Shore, N. Y.
Weighing equip., weighing units, liquid weighers.
C. W. Lang. 60

Goodyear Pumps Inc., New York, N. Y. 1341

Goulds Pumps, Inc., Seneca Falls, N. Y. 1288, 1290, 1292, 1294

Gow-Mac Instrument Co., Madison, N. J.
Gas analyzers, detectors for gas chromatographs, filaments for detectors, new portable gas analyzer.
J. L. McFadden, J. D. Carswell, Jr., R. G. Hungerford, J. F. Cooke, & others. 1246

Gray Tool Co., Houston, Texas. 1342, 1363

Great Lakes Carbon Corp., Mining & Mineral Products Div., Los Angeles, Calif.
Dicalite diatomite filteraids, diatomite mineral fillers, diluents and extenders, anode and electrode products.
J. E. Moran, sls. mgr.; G. G. Halvorsen, asst. sls. mgr.; S. H. Reynolds, gen. sls. mgr. 204

Great Western Manufacturing Co., Leavenworth, Kansas.
Sifting, screening, & cleaning machinery.
J. E. Baker, partner; R. Bunnel, rep.; G. F. Bailey, rep.; R. N. Bailey, rep. 216

Greif Bros. Cooperage Corp., Lindenhurst, N. Y.
Drums, barrels, & kegs.
F. D. Deahl, F. K. Duffy. 41

Grinnell Co., Providence, R. I.
Pipe hangers and supports, diaphragm valves, pipe fittings, welding fittings, unit heaters, prefab. piping, fire protection equip. 566

Gulf Publishing Co., Houston, Texas.
Books, magazines, catalogs.
W. Dudley, pres.; T. Nelson, gen. mgr.; R. M. de Sombre, asst. gen. mgr.; S. Sorrel, sls. rep. & others. 1035

Gump Co., B. F., Chicago, Ill.
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A. E. Hawkins, L. Jacobsen, J. F. Wilson, D. C. Creighton & others. 1024, 1026

Hamer Valves, Inc., Long Beach, Calif. 1236

Hamilton Kettles, Cincinnati, Ohio 623

Hanovia Lamp Div. Engelhard Ind., Inc., Newark, N. J. 192, 196, 225

Hapman Conveyors, Inc., Kalamazoo, Mich.
Tubular bulk materials conveyor.
O. K. Gardner, ex. v.p.; J. J. Wallace, gen. mgr.; C. R. Larson, ch. engr.; H. E. Ames, engr. 1358

Harbison-Walker Refractories Co., Pittsburgh, Pa. 1241, 1243

Hardinge Co., York, Pa.
Process equip., conical mills, sand filters & thickeners.
F. J. Winebrenner, adv. 582

Harman Associates, F. Ward, Div. Marine Model Co., Inc., Halesite, N. Y.
Scale model components for piping and structural layouts & scale models. 994

Harper Co., H. M., Morton Grove, Ill.
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E. M. Welty, sls. mgr.; K. J. Mulroy, sls. mgr.; R. D. Tuttle, mktg. mgr. 1032, 1034

Hastings-Raydist, Inc, Hampton, Va.
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Haynes Stellite Co., Div. of Union Carbide Corp., New York, N. Y.
Abrasion-, corrosion-, & high-temp. resistant alloys featuring bayonet heater in tantalum.
W. F. Campbell, R. T. Phillips, E. F. Leeman, J. S. Wood, & others. 460, 470

Heat Transfer Div. National-U. S. Radiator Corp., New York, N. Y. 850

Heil Process Equipment Corp., Cleveland, Ohio.
Corrosive fume handling equip., lined process equip., acid heating equip.
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Hercules Filter Corp., Hawthorne, N. J.
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Hercules Powder Co., Wilmington, Del. 916

Hetherington & Berner, Inc., Indianapolis, Ind. 1100

High Pressure Equipment Co., Inc., Erie, Pa. 1215, 1217

Hills-McCanna Co., Chicago, Ill.
Packless & plunger type metering & proportioning pumps.
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Hobam, Inc., Buffalo, N. Y. 1262, 1264

Hockmeyer & Co., Herman, New York, N. Y. 1178

Hoke, Inc., Cresskill, N. J.
Fluid control equip., valves, cylinders, & regulators.
W. O. Teeters, D. B. Salmon, R. J. Moody, E. B. Hitchcock, & others. 201

Horman & Co., Inc., F. R., Newark, N. J.
Filtration equipment.
H. E. Stapowick, v.p., sls. 977

Hospital Supply Co., Inc., New York N. Y.
"Climax" autoclaves, water stills & first-aid, industrial, & infirmary equip.
G. R. Kronish, v.p.; J. Kronish, pres.; B. Goldstein. 975

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Howe Scale Co., Subsidiary of Safety Industries, Inc., Rutland, Vt. 645

Howes Co., Inc., S., Silver Creek, N. Y.
"Eureka" granulator, bagging scale, & "Sanimix" machinery.
A. C. Barbeau, Jr., pres. & gen. mgr.; R. P. Wesley, v.p., sls.; J. R. Voneman, sls. rep. 1029

Hungerford & Terry, Inc., Clayton, N. J.
Water treatment equip. & accessories.
C. Hungerford, Jr., pres.; S. F. Alling, v.p., & gen. sls. mgr.; R. Davis, tech. dir.; sls. engrs. 1154, 1166

Hunt Machine Co., Rodney, Orange, Mass. 1240, 1242, 1244

Hydril Co., Los Angeles, Calif.
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E. M. Daniels, v.p.; W. H. Riggins, M. Wuslick. 1104

I-T-E Circuit Breaker Co., Philadelphia, Pa. 25

Illinois Water Treatment Co., Rockford, Ill.
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Industrial Chemical Sales Div., West Virginia Pulp & Paper Co., New York, N. Y. 924, 926

Industrial Div., Minneapolis-Honeywell Regulator Co., Philadelphia, Pa. 635

Industrial and Engineering Chemistry, New York, N. Y.
See Reinhold Publishing Corp.
H. S. Leonard, adv. sls. mgr.; R. Lewis, J. Cortissoz, E. Sullivan. 86

Industrial Filter & Pump Mfg. Co., Cicero, Ill. 1188 & 1202

Industrial Nucleonics Corp., Columbus, Ohio. 1418, 1420

Industrial Plastic Fabricators, Inc., Norwood, Mass.
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Industrial Products Engineering Co., Long Island City, N. Y. 1259

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Instruments and Systems Div., Engelhard Industries, E. Newark, N. J. 192, 196, 225

International Nickel Co., Inc., New York, N. Y.
Inco services, high & low temperature applications & corrosion.
W. H. Ahrens, E. J. Barrett, J. W. Carey, sls. engr.; W. R. Ferguson, sls. engrs. & reps. 509

International Process Equipment Co., Inc., International Clay Machinery Div., Dayton, Ohio.
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Ionics, Inc., Cambridge, Mass. 1137

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Jarco Services, Inc., Tulsa, Okla. 1343, 1345, 1347, 1349

Jeffrey Manufacturing Co., Columbus, Ohio.
Conveying, processing, mining equip.
J. E. M. Wilson, v.p., sls.; C. G. Hawley, gen. sls. mgr. 97

Jenkins Bros., New York, N. Y. 409

Jerguson Gage & Valve Co., Burlington, Mass. 1211, 1213

Johns-Manville Sales Corp., New York, N. Y.
"Chempac" products, "Transite" pipe, filter aids, vents.
Sls., mgrs.; res. engrs.; sls. reps. 172, 176

Journal of Agricultural & Food Chemistry, New York, N. Y. & Washington, D. C. 86

Kanigen Div. General American Transportation Corp., Chicago, Ill. 435, 436, 442

Keasbey & Mattison Co., Ambler, Pa. 822

Kennedy Van Saun Mfg. & Engineering Corp., New York, N. Y.
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Kewaunee Mfg. Co., Adrian, Mich.
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W. B. Quantock, adv. mgr.; sls. engrs. 398

Kimble Glass Co., subsidiary of Owens-Illinois, Toledo, Ohio.
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J. J. Moran, F. T. Ritter, Jr., W. H. Sweet, A. C. Peters, others. 390

Knapp Mills, Inc., Long Island City, N. Y.
Chem. process equip., corrosion-resistant lead & lead-lined prods.
A. P. Knapp, chairman. 175

Komline-Sanderson Engineering Corp., Peapack, N. J.
Industrial filter equip., horizontal pilot plant filter, rotary drum pilot plant filter. 1307; 1309

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Operator checks Ni-Resist pump at Pennsalt Chemical's Portland plant. This particular unit was manufactured by A. R. Wilfley & Sons, Inc. of Denver, Colorado, and pumps caustic at a concentration of 50%. The Duriron Company, Inc. of Dayton, Ohio, also supplied Ni-Resist pumps for the plant.

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Koven Fabricators, Inc., Dover, N. J. **74**

LKB Instruments, Inc., Silver Spring, Md. **1422**

Laboratory Equipment Corp., St. Joseph, Mich. **905**

Laboratory Furniture Co., Inc., Mineola, N. Y.
Lab. furniture & equip.
J. M. Liptay, pres.; R. H. Elmore, ex. v.p.; E. J. Leech, v.p., sls.; D. Flood, sls.; others. **309**

Laboratory Glass & Instruments Corp., New York, N. Y.
Flash evaporators, chloride titrator, fraction collector, desalter, other instruments.
J. Buchler, pres.; O. Gross, sls. mgr. **369**

LaBour Co., Inc., Elkhart, Ind.
Centrifugal pumps, valves.
W. A. Schumacher, M. E. Toney, J. R. Muehlberg. **42**

Ladish Co., Cudahy, Wis.
Ind. pumps., corrosion-resistant valves, pipe fittings in carbon, SS, alloy, aluminum.
R. Meek, sls. mgr.; F. Hinrichs, v.p. **63**

Ladish Co., Tri-Clover Div., Kenosha, Wis. **63**

Lapp Insulator Co., Inc., Process Equipment Div., Le Roy, N. Y.
Process equip., chem. porcelain equip. "Pulsafeeder" proportioning pumps.
R. Jenner, pres.; B. Mills, ex. v.p.; others. **696**

Lawrence Pumps, Inc., Lawrence, Mass.
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V. J. Mill, Jr., sls. mgr.; others. **852**

Lead Industries Assoc., New York, N. Y.
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R. L. Ziegfeld, secy.; S. F. Radtke, res. dir.; others. **816**

Lead Lined Iron Pipe Co., Wakefield, Mass.
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J. D., D. F., T. E. Dwyer. **70**

Lebanon Steel Foundry, Lebanon, Pa.
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J. K. Louden, exec. v.p.; J. M. Quinn, plant mgr.; W. H. Flynn, gen. sls. mgr.; sls. engrs. **20**

Lee Metal Products Co., Phillipsburg, Pa.
Corrosion resisting processing equip., tanks, steam-jacketed kettles.
J. M. Lee, pres.; W. J. Scarlett, gen. mgr.; others. **1384**

Lehigh Fan & Blower Div., Fuller Co., Catasauqua, Pa. **446**

Lehmann Co., Inc., J. M., Lyndhurst, N. J.
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F. Ahlfeld, ex. v.p. & gen. mgr.; H. F. Croot, Jr., v.p.; C. W. Muller, sls. mgr.; others. **1429, 1431, 1446**

Leitz, Inc., E., Scientific Instrument Div., New York, N. Y.
Stone titrators, chem. res. microscopes, photometers, polarimeters.
K. M. Kubierschky, G. Stone, P. Bartels. **1383**

Leslie Co., Lyndhurst, N. J. **1333**

Link-Belt Co., Chicago, Ill. **165**

Logan Emergency Showers, Inc., Glendale, Calif. **883**

Louisville Dryer Div., General American Transportation Corp., Chicago, Ill. **435, 436, 442**

Lunkenheimer Co., Cincinnati, Ohio.
Corrosion-resistant valves, fittings.
P. M. Arnall, pres., gen. mgr.; E. P. Lunken, v.p.; M. W. Pauly, v.p., sls.; E. F. Riopelle, v.p., eng. res. **1380, 1382**

McFarland Engineering & Pump Co., Houston, Texas. **1342, 1363**

McGraw-Hill Book Co., Inc., New York, N. Y.
Tech. publications in chem. field. **974**

McGraw-Hill Publishing Co., New York, N. Y. **432, 481**

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A. J. McIntosh, pres.; A. N. Karp, app. engr.; F. L. Goetz, app. engr.; R. S. Jones, app. engr. **1343, 1345, 1347, 1349**

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Manton-Gaulin Mfg. Co., Inc., Everett, Mass.
Homogenizers, high pressure pumps, lab. size colloid mill.
D. G. Colony, pres.; G. W. Eldridge, gen. sls. mgr.; J. J. Dwyer, ind. sls. mgr. **51**

Marindus Co., Inc., New York, N. Y. **1440**

Martin Eng. Co., Neponset, Ill.
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W. J. & W. E. Dougherty, E. F. & E. H. Peterson. **1118**

Master Electric Co., Div. of Reliance Electric & Engineering Co., Dayton, Ohio. **10**

Mazzoni, G., S.p.A. Busto Arsizio, Italy.
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L. J. Monticelli. **1412**

Meccaniche Moderne, Busto Arsizio, Italy. **1429, 1431, 1446**

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Metal-Cladding, Inc., North Tonawanda, N. Y.
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W. R. Wardrop, T. Bowdren, R. Quick, sls. reps. **1378**

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R. C. Wade, mgr.; M. D. Banus, dir. res.; A. A. Hinckley, R. E. Minor. **964**

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H. M. Plant, pres.; S. Fiance, ex. v.p.; W. A. Reed, v.p., steel sls.; A. R. Salveson, v.p., wood sls. **356**

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V. Makin, mgr. prec. metals; G. Hammond, mkt. mgr., platinum prod.; C. Grube, E. mgr. **1094**

Metalsalts Corp., Hawthorne, N. J. **933**

Mettler Instrument Corp., Hightstown, N. J.
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F. C. Tobler, pres.; D. L. Jones, v.p., sls.; sls. reps. **339**

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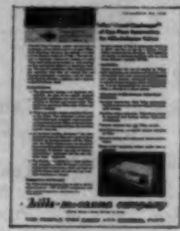

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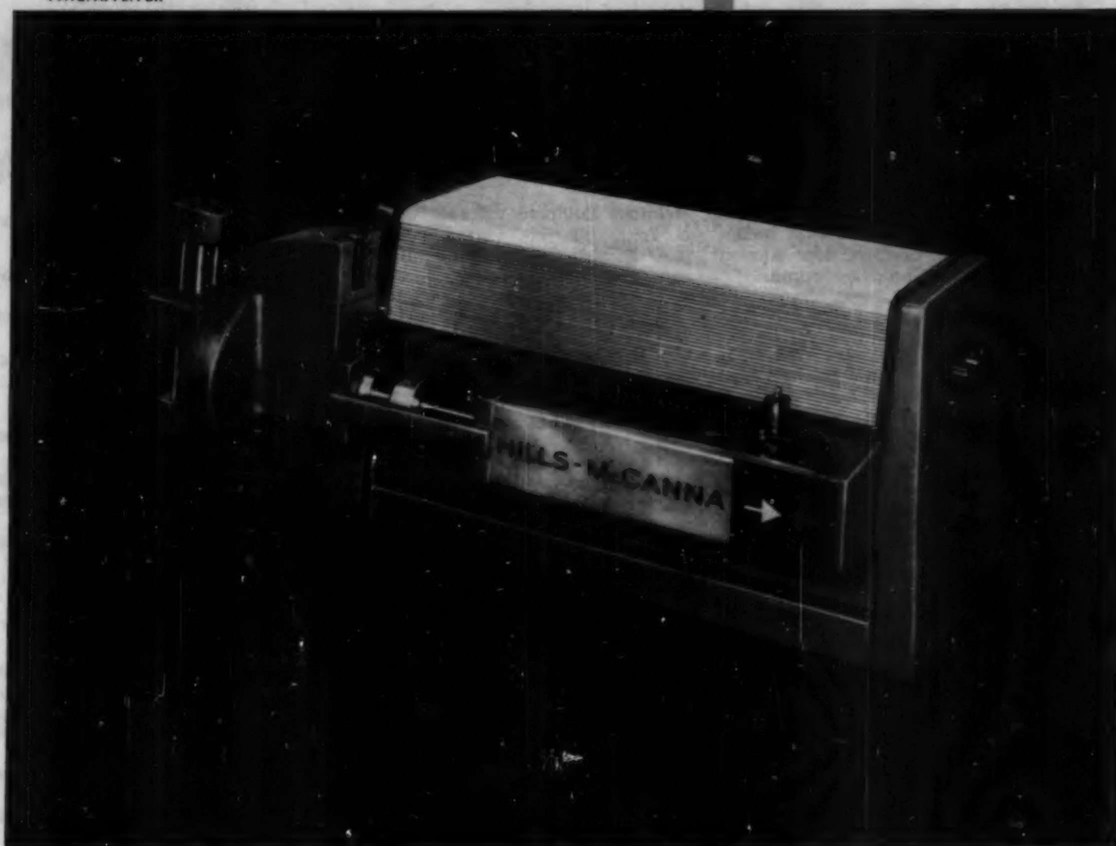

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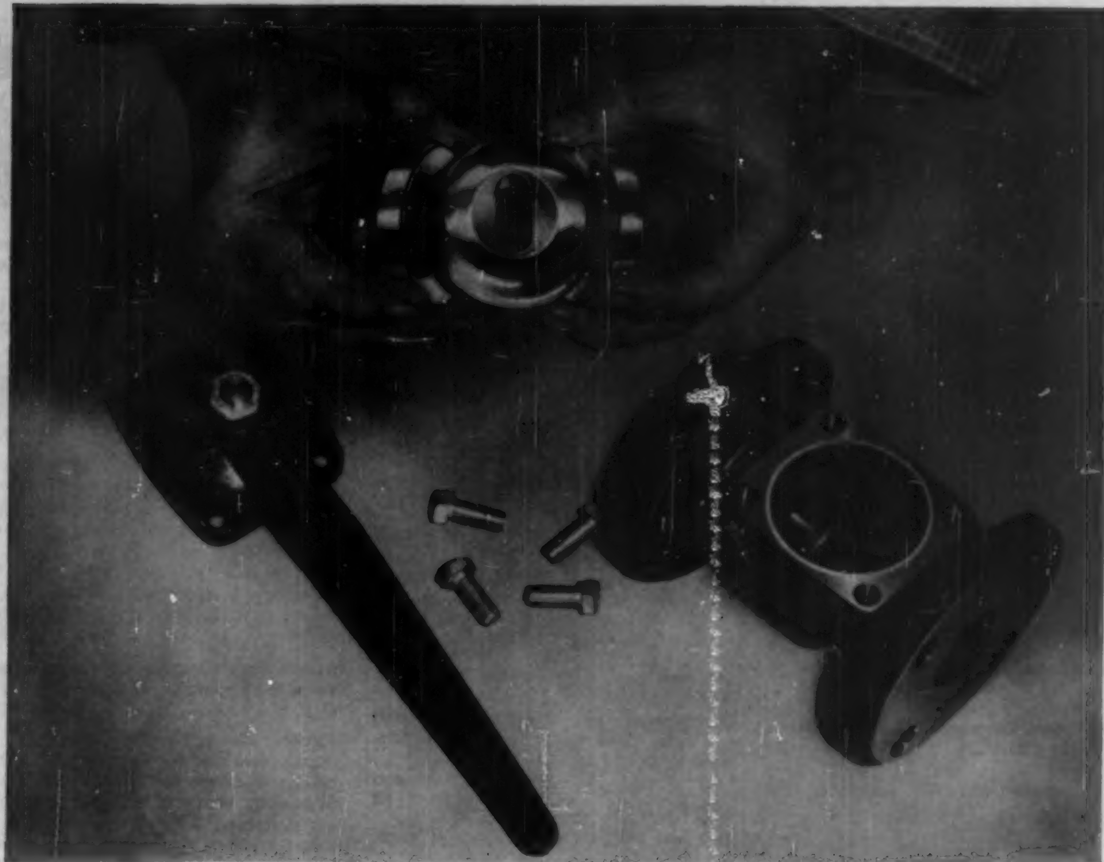

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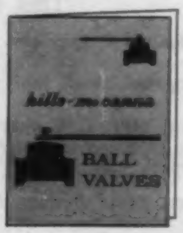

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Micro Metallic Div. Pall Corp., Glen Cove, N. Y. 1012, 1014

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H. Galanty, v.p. 1010

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N. R. Bart, H. Herman, F. Raher, H. Margolin, others. 1091

Milton Roy Co., Philadelphia, Pa. 610

Mine Safety Appliances Co., Pittsburgh, Pa. 14, 16

Minerals & Chemicals Corp. of America, Menlo Park, N. J. 950

Minneapolis-Honeywell Regulator Co., Industrial Div., Philadelphia, Pa. 635

Mission Mfg. Co., Houston, Texas. 1417 1419

Mixing Equipment Co., Inc., Rochester, N. Y.
Fluid mixers, multistage mixing column, top-entering and portable mixers. 146

Monarch Mfg. Works, Inc., Philadelphia, Pa.
Industrial spray nozzles in SS, brass, hard rubber, stoneware, red brass.
T. W. Murphy, pres.; E. B. Frame, v.p.; W. H. Hulick, mech. engr.; R. Van Zandt, mech. engr. 881

Monsanto Chemical Co., St. Louis, Mo.
Exhibit connected with CBS-TV program "Conquest," science documentary on cancer research, oceanography, tuberculosis, etc.
F. Gudemann, CBS staff. 922

Moore & Co., Samuel, Mantua, Ohio.
"Dekoron" instrument tubing products.
F. H. Olton, pres.; R. B. Burnham, gen. sls. mgr.; sls. rep. 1182, 1184

Morehouse-Cowles, Inc., Los Angeles, Calif.
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Multi-Metal Wire Cloth Co., Inc., New York, N. Y.
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R. A. Stern, sls. mgr.; O. W. Hintze, asst. sls. mgr.; J. Taylor, staff engr. 191

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E. Goldberg, pres.; J. P. Powell, v.p.; D. W. Kallman, sls. mgr.; R. P. Madsen, sls. engr. 1201

Namco Machinery, Inc., Brooklyn, N. Y.
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M. E. Cole, R. C. Jackson, S. F. Breier. 365

Nash Engineering Co., South Norwalk, Conn. 238

National Carbon Co., Div. of Union Carbide Corp., New York, N. Y.
Graphite process equip., "G" Globe valve, grades of activated carbon.
J. F. Brauning, J. B. Brown, W. M. Gaylord, D. S. Glass, others. 460, 470

National Drying Machinery Co., Philadelphia, Pa.
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A. W. Keyser, gen. mgr.; C. Schlecht, ch. eng. & sls. 1112, 1114

National Dust Collector Corp., Chicago, Ill.
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R. L. McIlvaine, pres.; E. B. Henby, v.p.; sls. reps. 695

National Engineering Co., Chicago, Ill.
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J. Stewart, sls. mgr.; R. L. McIlvaine, ex. v.p.; sls. engrs.; mgrs. 695

National Filter Media Corp., New Haven, Conn.
Filter fabrics, polypropylene filter cloth. 1113

National Lead Co., Titanium Alloy Mfg. Div., New York, N. Y. 234

National Rosin Oil Products, Inc., Savannah, Ga. 917

National Tube Div. United States Steel Corp., Pittsburgh, Pa. 590

National-U. S. Radiator Corp., Johnstown, Pa.
Heating, air conditioning, industrial products & equip.
R. A. Specht, mgr.; C. E. Hanson, sls. mgr.; E. C. Kallman, asst. mgr.; P. G. Tomalin, gen. mgr. 850

Nero-Products Dept., Great Lakes Carbon Corp., Chicago, Ill. 204

Nettco Corp., Everett, Mass.
"Flomix" demonstration unit, portable mixers.
C. Pennucci, J. Lennon, E. Page, J. Elsnor, others. 79

New Brunswick Scientific Co., New Brunswick, N. J. 324

New York Laboratory Supply Co., Inc., New York, N. Y.
Instruments & apparatus, "mechanical hand" clamp, "flame master" gas burner.
R. Johnson, H. Clark, F. Rossing, L. Resnick, others. 1022

Newark Wire Cloth Co., Newark, N. J. 183

Niagara Blower Co., New York, N. Y. 655

Niagara Filters Div. American Machine & Metals, Inc., E. Moline, Ill.
"Batch-Miser" Niagara horizontal plate filter & automatic "H" style pressure leaf filter.
R. M. Hames, gen. sls. mgr.; L. Gray, sls. & app. eng.; K. Anderson, ch. engr.; W. Steiner, sls. & app. engr.; others. 456, 506, 556

Nichols Engineering & Research Corp., Nerco-Niro Spray Dryer Div., New York, N. Y. 624

Norcross Corp., Newton Mass.
Viscometers for process control applications in diversified industries, multi-measuring element, recording-controlling systems.
A. S. & R. A. Norcross, R. S. Davis, Jr. 443

Norcross Companies, Sterling E., Kem-Feed Div., Bloomfield, N. J., "Pour-Portioner." 991

Nordstrom Valve Div., Rockwell Mfg. Co., Pittsburgh, Pa. 69

North American Philips Co., Inc., Cryogenics Div., Mount Vernon, N. Y.
Cryogenerators.
J. Meisler, tech. mgr.; A. Krasner, J. Suissa, sls. mgr. 935

North-Erie & American Process Equipment Div., National—U. S. Radiator Corp., Middletown, Pa. 850

Norton Co., Worcester, Mass.
Catalyst carriers, ceramic porous tubes & plates, "Rokide" ceramic coatings, refractories.
G. H. Powers, mgr.; W. G. Fallon, gen. mgr.; F. B. Huke, mgr.; F. Paulson, eng.; others. 1289, 1291

NoVo, Div. Industrial Enterprises, Inc., Chicago, Ill.
Sonic screening machines, lab. sieve testers.
C. F. Newburg, pres.; C. E. Meginnis, v.p., sls.; W. L. Hemingway, mgr.; D. M. Dewey, ch. proj. engr.; others. 1030

Nukem Products Corp, Buffalo, N. Y. 1072

Okadee Co., Chicago, Ill.
Valves & valve-operating mechanisms.

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cylinder & power operation of steel & SS valves.
C. G. Learned, ex. v.p.; C. W. Ploen, v.p.; D. P. Rennhack, asst. ch. eng.; D. M. North, eng. dept., others. 1386

Overseas Div., General American Transportation Corp., New York, N. Y. 435, 436, 442

Owens-Corning Fiberglas Corp., Toledo, Ohio. 1266

Oxy-Catalyst, Inc., Wayne, Pa.
Systems for industrial air pollution control.
J. H. Houdry, pres.; C. T. Hayes, mgr.; ind. div. 1343, 1345, 1347, 1349

Pacific Valves, Inc., Long Beach, Calif.
Valves for steam service, high pressure gas service, corrosive service applications, low temperature service, valves for nuclear service.
R. C. Macauley, v.p. & sales mgr.; F. G. Shlemmer, v.p. & mgr., R. E. Baumann, div. mgr.; A. Peeler, sales eng. 1315, 1317

Package Research Lab., Rockaway, N. J.
Returnable and expendable shipping containers.
H. Dinsmore, G. Babcock, G. Sheldon, reps. 1261, 1263

Packed Column Corp., New York, N. Y.
"Goodloe" column packing, "Panapak" column packing, "Stedman" column packing.
L. B. Bragg, pres.; R. L. Bragg, sls. 1171

Pall Corp., Micro Metallic Div., Glen Cove, N. Y. 1012, 1014

Pallmann Pulverizers Co., Garden City, L. I., N. Y. 1371, 1373

Palo Lab. Supplies, Inc., New York, N. Y.
Lab. and scientific apparatus, chromatography equip., stirrers & shakers, handling items.
R. M. Levin, v.p.; I. Rosen, sls. staff. 385

Pangborn Corp., Hagerstown, Md.
Dust collectors, Type "CO" collecter, wet dust collector.
W. O. Vedder, v.p.; A. J. Buckley, gen. sls. mgr., A. L. Gardner, adv. mgr.; sls. engrs. 681

Paquet & Co., Inc., M. Airsonic Industrial Stethoscopes, New York, N. Y. 1374

Parker Fittings & Hose Div., Div. of Parker-Hannifin Corp., Cleveland, Ohio. 431

Parker-Hannifin Corp., Cleveland, Ohio. 431

Parker Seal Co., Div., of Parker-Hannifin Corp., Culver City, Calif. 431

Parks-Cramer Co., Fitchburg, Mass. 55

Patterson Foundry and Machine Co., E. Liverpool, Ohio.
Type "K" agitator, "Conaform" vacuum dryer, "ThoroBlender", scale model of Patterson synthetic resin system.
A. T. Jacobson, sales mgr.; R. B. Mack, prod. mgr.; C. G. Keirnan, prod. mgr.; R. H. Jebens, app. res. mgr. 154

Patterson-Kelley Co., Inc., E. Stroudsburg, Pa.
Heat transfer & chem. process equip., water heaters, heat exchangers, blenders, dryers. 188, 215

Peabody Engineering Corp., New York, N. Y. 1321

Peerless Mfg. Co., Dallas, Texas. 1008

Peerless Pump Div., Food Machinery and Chemical Corp., Los Angeles, Calif. 831

Pennsylvania Fluorocarbon Co., Inc., Philadelphia, Pa.
Teflon extrusions, bushings, bearings, special shapes and profiles, plastic material products.
J. W. Burley, v.p. & sls. mgr.; B. E. Ely., Jr., pres.; I. T. Clement, res. & devel. engr. 969

Perkin-Elmer Corp., Instrument Div., Norwalk, Conn. 386

Perkin Engineering Corp., El Segundo, Calif.
Semi-conductor rectifier, silicon rectifier.
P. Diamond, pres.; L. Keitz, mgr.; E. J. Diebold, tech. mgr.; K. Holtzclaw, app. eng. 996

Perlite Dept., Mining & Mineral Products Div. Great Lakes Carbon Corp., Los Angeles, Calif. 204

Permutit Co., Div. of Pfaudler Permutit Inc., New York, N. Y. 110, 141

Pfaudler Co., Div. of Pfaudler Permutit Inc., Rochester, N. Y.
Reactor display, "Titan" centrifuge, "Colloidaire" separator. 110, 141

Philadelphia Gear Corp., Philadelphia, Pa.
Fluid mixers, valve operators, new side-entering mixer.
R. C. Ball, Jr., v.p.; M. C. Donze, v.p.; R. S. Dobbs, v.p.; H. L. Murray, Jr. sls. mgr. 123

Photovolt Corp., New York, N. Y.
pH meters, densitometers, colorimeters, fluorescence meters, photometers, multiple-reflection galvanometer.
H. C. Sondergaard, G. B. Levy. 389

Pick Mfg. Co., West Bend, Wis.
Instantaneous steam injection hot water heaters.
A. E. Pick, pres., O. L. Daily, sls. mgr., heater div. 1343, 1345, 1347, 1349

Pittsburgh Corning Corp., Pittsburgh, Pa. 1239

Plastic Metals Div., National — U.S. Radiator Corp., New York, N. Y. 850

Plastics Molding Div., General American Transportation Corp., Chicago, Ill. 435, 436, 442

Plate & Welding Div., General American Transportation Corp., Chicago, Ill. 435, 436, 442

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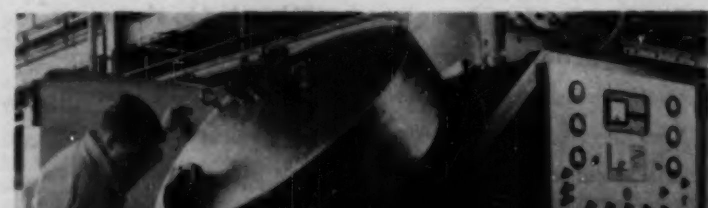

Centrifugal Molecular High Vacuum Still with 36-in. diam. rotor will be a feature of Consolidated Vacuum Corp.'s exhibit.

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Platecoil Div., Tranter Manufacturing, Inc., Lansing, Mich.
Steam specialties.
J. R. Tranter, pres.-gen'l mgr.; H. E. Guyselman, ex. v.p.; L. S. Worthington, secy. & dir. adv.; S. J. Stowell, sls. mgr. **1206, 1208, 1210**

Pocono Fabricators, Inc., E. Stroudsburg, Pa. **188, 215**

Podbielniak, Inc., Chicago, Ill. **595**

Porcelain Div., Ferro Corp., E. Liverpool, Ohio.
Arclite, Porox, Arclite wear blocks, spheres for catalyst bed supports.
C. W. Gerster, gen'l. mgr. **154**

Porter, George K., Inc., Hatfield, Pa. **1134, 1136**

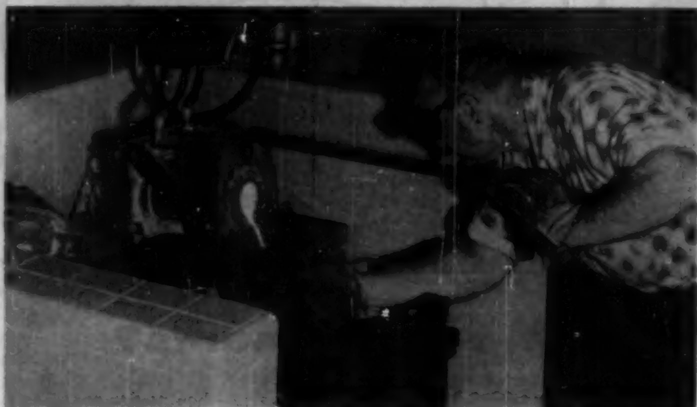
Precision Scientific Co., Chicago, Ill.
Lab. ovens, ovens, vacuum pumps, chromatograph, petrol. test equip.
J. J. Kinsella, v.p. & sales mgr.; J. Black, asst. sls. mgr.; W. G. Kells, N. Y. dist. mgr. **370, 372**

Precision Thermometer & Instrument Co., Philadelphia, Pa. **1401**

Premier Equipment Co., Long Island City, N. Y. **1259**

Premier Mill Corp., New York, N. Y. **1391**

Pressed Steel Tank Co., Milwaukee, Wis.
Rocket and missile parts and cylinders, shipping and storing containers.
N. A. Evans, v.p., sls.; T. V. Montgomery, mgr.; J. W. Flynn, sls. mgr. **631**



Platinum melting at the General Plate Products Group of Metals & Control Div., Texas Instrument Inc. New plate platinum products will be shown.

Posey Iron Works, Inc., Lancaster, Pa. **1407**

Potter-Bowser Div. of Bowser, Inc., Ft. Wayne, Ind. **396**

Potts Co., Horace T., Speedline Fittings Div., Philadelphia, Pa.
SS fittings, process piping "workshop" where welding of pipe & fittings will be performed.
J. W. Reckard, gen. sls. mgr.; W. H. Van Horn, mgr.; A. Martin, dist. sls. mgr.; M. F. Thomas, dist. sls. mgr.; G. A. Parker, mgr. **980**

Powell Company, The Wm., Cincinnati, Ohio.
Bronze, iron, steel, corrosion-resistant valves.
W. E. Heilig, v.p.; M. G. Bolinger, metallurgist; C. J. Keilman, v.p., N. Y. **133**

Prater Pulverizer Co., Chicago, Ill.
Rotary airlock feeders for dust control and pneumatic conveying operations.
P. E. McKamy, J. Kotilinek, G. F. Thomas. **904-906**

Pressure Products Co., Charleston, W. Va.
Sight glass in SS, ASA flange, lens assembly.
J. R. Osborne, v.p.; R. C. Osborne, sales mgr.; A. E. Baccini, tech. rep.; G. Towers, tech. rep. **1409**

Pressure Products Industries, Inc. Hatboro, Pa.
Stirred press. reactors, diaphragm gas comp., valves, gauges, pumps.
R. C. Wolf, pres.; J. C. Bowen, v.p.; J. G. Leaming, treas. **1367, 1369**

Process Filters Div., Bowser, Inc., Fort Wayne, Ind.
Four basic type chem. filters.
R. E. Shields, gen. mgr.; E. Kania, ch. engr.; C. Foster, sls. mgr.; proc. sls. engrs. **1115**

Proctor & Schwartz, Inc., Philadelphia, Pa. **684**

Productive Equipment Corp., Chicago, Ill.
Vibrating screens.
L. H. Lehman, sls. mgr.; L. M. Haluch, asst. sls. mgr.; C. B. Smith, sls. rep. **224**

Protectoseal Company, Chicago, Ill.
Safety equipment.
J. W. Mock, sls. dir.; G. T. McCarty, sls. eng.; R. P. Gaffke, sls. eng. **1286**

Pulva Corp, Perth Amboy, N. J.
"Com-Bin" feeder, "PULVA-SIZER", "PULVALVE," crusher.
W. W. McNamara, v.p.; F. Kolisek, pres. **220**

Pulverizing Machinery Div., Metals Disintegrating Co., Inc., Summit, N. J.
Dust collectors, 9.4 "Mikro-Pulsaire" model, grinding mills.
D. Bradley, v.p., gen. mgr.; R. McWhorter, gen. sls. mgr., sls. reps. **632**

Purolator Products, Inc., Rahway, N. J.
Porous metal filters & media of various types for all fluids.
J. P. Kovacs, v.p.; E. L. Sandberg, tech. sls. eng.; C. J. Porzenheim, tech. sls eng.; E. J. Van Lier. **15**

Putman Publishing Co., Chicago, Ill. **880**

Putnam Co., Inc., J. L., Houlton, Me.
Valves, actuators.
J. L. Putnam, genl. sls. mgr.; A. C. Daniels, Sr., asst. sls. mgr.; L. Rand, sls. prom. dir. **1040, 1042**

Quaker Oats Co., Chemicals Div., Chicago, Ill.
New products, devel. in chemicals, furfural and derivatives.
H. R. Duffey, v.p.; F. F. McKinney, sls. mgr.; dist. sls. mgrs. **953**

RKL Controls, Inc., Hainesport, N. J. **1405**

Radiation Counter Laboratories, Skokie, Ill. **1071**

Radiation Electronics Co., Skokie, Ill.
Radiation thermometers, preamplifiers, control units, "Thermodot" radiation thermometer Models TD-1 and TD-3.
H. L. Berman, mgr. **1155, 1157**

Rapids Machinery Co., Inc., Marion, Iowa. **1162**

Raybestos-Manhattan, Inc., Passaic, N. J. **820**

Raymond Div., Combustion Engineering, Inc., Chicago, Ill. **646**

Raytheon Co., Industrial Apparatus Div., Manchester, N. H. **1442**

Read Standard, Div. of Capitol Products Corp., York, Pa. **162**

Redevco, Jersey City, N. J. **1098**

Reeves Pulley Co., Div. of Reliance Electric & Engineering Co., Columbus, Ind. **10**

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CEP CHEM SHOW SPECIAL

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Reinhold Publishing Corp., New York, N. Y.
ACS publications, chem. engr. catalogs, tech. book lists.
D. N. Livingston, sls. prom. mgr. **86**

Reliance Electric and Engineering Co., Cleveland, Ohio. **10**

Renneburg & Sons Co., Edw., Baltimore, Md.
"Dehydro-Mat" dryers and coolers.
J. N. Renneburg, pres.; E. J. Leister, sls. mgr.; G. E. Lang, head, engr. dept. **1078**

Republic Lead Equipment Co., Cleveland, Ohio. **111**

Republic Seitz Filter Corp., Newark, N. J.
Liquid filters, filter media.
J. Haims, sls. mgr., W. A. Whitney, sls. rep. **977**

Republic Steel Corp., Cleveland, Ohio. **68**

Research Controls, Tulsa, Okla. **1186**

Research & Development Dept., General American Transportation Corp., Chicago, Ill. **435, 436, 442**

Resistoflex Corp., Roseland, N. J.
Corrosion-proof steel piping, components lined with Fluroflex-T.
893, 895 897

Rheem Manufacturing Co., Linden, N. J. **808, 810**

Richardson Scale Co., Clifton, N. J.
Weighing, packing, proportioning machy., scale for automatic batch formulation and gross weighing, bagging scale Model GA-17.
Dist. mgrs. **1151, 1153**

Rietz Mfg. Co., West Chester, Pa.
RE-6 "Extructor" and RI-2 Disintegrator.
C. B. Schreffler, W. S. Enochian, A. B. Dunwody, M. Hobson. **1231**

Robbins & Myers, Inc., Moyno Pump Div., Springfield, Ohio. **1254**

Robertshaw-Fulton Controls Co., Aeronautical & Instrument Div., Anaheim, Calif.
Industrial controls, level detection, measurement, continuous level indicator.
D. E. Teaford, mgr.; L. Cuckler, dist. sls. mgr.; J. W. Philippi and D. Lightstone, app. engs. **1366, 1368**

Robertshaw-Fulton Controls Co., Fulton Sylphon Div., Knoxville, Tenn.
Temp. and pressure controls, packless valves.
L. S. Dysart, sls. mgr.; A. W. Roat, sls. engr. **1293**

Rochester Manufacturing Co., Inc., Rochester, N. Y. **943**

Platinum laboratory equipment will be a feature of Metals & Controls Div., Texas Instrument Inc., booth.

Rockwell Manufacturing Co., Pittsburgh, Pa.
Complete line special-coated, corrosion-resistant valves.
H. Gottwald, asst. v.p., valve prod.; J. Harris, asst. mgr., chem. & ref. valve sls.; R. Johnson, Eastern sls. mgr.; C. Kentler, N. Y. sls. mgr. **69**

Rockwood Sprinkler Co., Div. of Gamewell Co., Worcester, Mass.
Ball valves in SS, nozzles, extinguishing agents.
J. J. Ryan, sls. mgr.; A. H. O'Connell, sls. mgr.; F. Steiner, adv. mgr.; P. Lofgren, asst. sls. mgr.
1238, 1271, 1273

Ross & Son Co., Inc., Charles, Brooklyn, N. Y.
Mixing & grinding equip., double planetary change can mixers.
C. K. Ross, pres.; J. G. Teleky, engr.; R. M. Ross, v.p. & treas.; W. E. Muller. **983, 985**

Roy, Milton, Co., Phila., Pa.
Chem. instrumentation, "Magnox" oxygen meter, "Chemalyzer" colorimeter, and pneumatic and electrical control systems.
R. T. Sheen, pres.; W. T. Griffith, v.p.; J. Procopi, sls. mgr. **610**

Ruska Instrument Corp., Houston, Texas. **1071**

Safety Industries Inc., New Haven, Conn.
"Contromil," impact mill, centrifugal mixer, abrasion and corrosion-resistant materials.
R. J. Hoskins, v.p., mktg.; J. B. Stearns, asst. mgr.; A. J. Tenner, chf. engr. **645**

Saran Lined Pipe Co., Ferndale, Mich. **913**

Sarco Company, Inc., New York, N. Y.
Temp. controls, steam traps, strainers.
A. Milnes, D. Roland, J. Paster. **93**

Sargent's, C. G., Sons Corp., Graniteville, Mass.
Feeding and drying equip., extruder & granulator.
F. S. Smith, treas., gen. mgr.; R. W. Hall, ch. engr.; D. A. Crocker, sls. dept.; R. D. Lambert. **1375, 1377**

Sargent & Co., E. H., Chicago, Ill. **1394**

Scam Instrument Corp., Chicago, Ill. **1230, 1232**

Schmieg Industries, Inc., Long Island City, N. Y. **1259**

Schutte and Koerting Co., Cornwells Heights, Pa. **61**

Schutz-O'Neill Co., Minneapolis, Minn.
"Vibration" vibrating ball mill, "Ultra-Classifier," air classifier.
A. Trommer, sls. mgr. **1028**

Scientific Development Co., State College, Pa.
Protruded distillation packing equip., constant temp. bath, viscometers. **382**

Scientific Glass Apparatus Co., Inc., Bloomfield, N. J.
Chem. lab. glassware, interchangeable ground glass joints, rotating evaporators, microscopes, extractors, chromatographic equip.
W. Geyer, Jr., gen. mgr.; J. L. Miller, sls. mgr.; sls. reps. **332**

Sealol Corp., Providence, R. I.
Mech. seals for rotating shafts, check valves, swivel and rotary joints.
H. Greiner, div. mgr.; E. Price, sls. mgr.; J. Feltman, sls. engr.; W. Aiken, proj. engr. **1281**

Seavy & Sons, M. J., New York, N. Y.
Glass fractional distillation equip., columns, still heads, receivers, accessories.
H. G. Seavy, part.; G. R. Seavy, part.; W. H. Brelhan, sls. mgr.; A. G. Murphy. **1071**

Selas Corp. of America, Dresher, Pa.
Micro-processing and heating equip., drying machinery, hydrogen generation and purification plant.
P. Berg, asst. mgr.; E. S. Kopecki, mgr.; G. V. Jordan, mgr.; engrs. & sls. reps. **979, 981**

Sellers Injector Corp., Philadelphia, Pa.
Jet cleaners, shut-off valve.
V. F. Sheronas, pres.; I. P. Pedrick, ex. v.p.; J. W. Lord, Jr., sls. mgr.; W. H. Deerfield, N. Y. rep. **1376**

Sharples Corp., Philadelphia, Pa.
Centrifuges, dehydrator, "Nozljector," micromerograph. **485**

Sheet and Strip Div., Republic Steel Corp., Cleveland, Ohio. **68**

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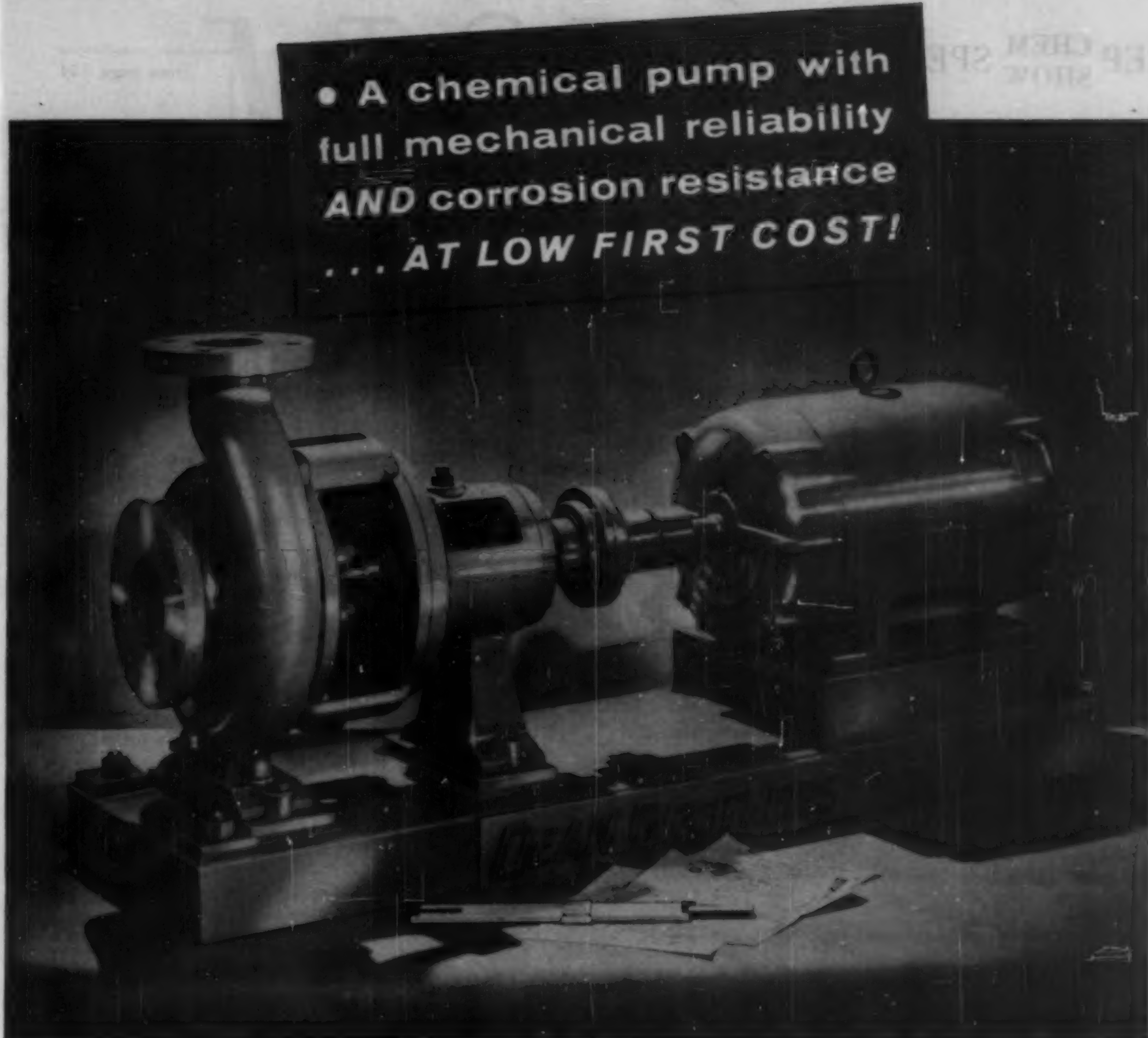

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Sheldon Equipment Co., E. H., Muskegon, Mich. 336

Shriver & Co., Inc., T., Harrison, N. J. Filtration & pumping equip., vertical leaf pressure filter, filter press, diaphragm pump. 473

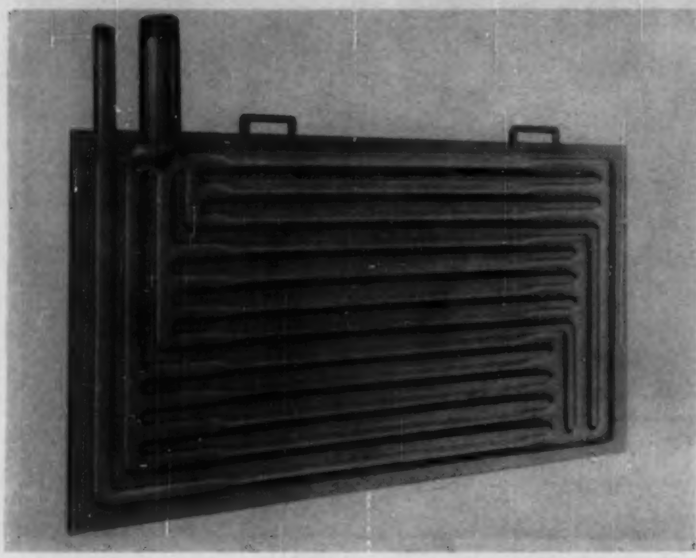
Sier-Bath Gear & Pump Co., Inc., No. Bergen, N. J. 306

Sigmamotor Inc., Middleport, N. Y. Pumping equipment, kinetic clamp unit, metering.
V. G. Hungerford, pres.; P. J. Slattery, genl. mgr.; R. Tripp, N. J. rep. 1099

Snyder Corp., Arthur Colton Co. Div., Detroit, Mich. 50

Sonic Engineering Corp., Stamford, Conn.
Homogenizers.
E. C. Cottell, pres.; J. Jacobs III., v.p.; J. S. Kornfeld, sls. mgr. 1122

Sorvall, Inc. Ivan, Norwalk, Conn.
Continuous flow system, centrifuges, rotors, mixers, chromatography instruments.
N. L. Christensen, v.p.; C. G. Lindgren, v.p.; S. Nordstrom, asst. v.p.; J. Blum, chf. designer. 342



Multi-zone "Platecoil" can be applied to heating and cooling requirements where pressures up to 250 psi must be met. Platecoil Div., Tranter Mfg.

Simon-Carter Company, Minneapolis, Minn.
Disc separator, cylinder separator, precision grader. 1096

Simpson Co., Orville, Cincinnati, Ohio. "ROTEX" screener, "ROTEX" cooler.
V. Corbin, sls. mgr. 1150

Sly Manufacturing Co., W. W., Cleveland, Ohio.
Filters, traveler, ovens.
C. R. Sare, pres.; W. L. Kurz, secy.; A. H. Jones, v.p.; E. M. Falk, sls. mgr. 73

Smith Co., T. L., Milwaukee, Wis.
Turbine mixer.
R. W. Smith, pres.; W. A. Clayton, v.p.; R. R. Bains, sls. mgr.; T. K. Stromsted, res. engr., W. H. Smart, asst. dir. sls. 986

Southwestern Engineering Co., Los Angeles, Calif.
"Vibro equip., "Sweco" energy mill, screen separators and feeders.
R. W. Kenagy, adv. mgr. 1250, 1252

Sparkler Manufacturing Co., Mundelein, Ill.
Filtration equip., Model HRC filter.
F. Kracklauer, G. Garland, L. Garland, J. Sharbaugh. 56

Specialty Machinery Corp., Newark, N.J. 1413, 1430

Speedline Fittings Div., Horace T. Potts Co., Philadelphia, Pa. 980

Sperry & Co., D. R., Batavia, Ill. 1362

Spray Engineering Co., Burlington, Mass.
Spray nozzles, spray heads.
J. S. Hartley, F. L. Stoughton, J. F. Whittemore. 1229

Spraying Systems, Co., Bellwood, Ill.
Spray nozzles.
R. Miller, C. A. Harry, J. Lawrence, R. Krause. 914

Sprout, Waldron & Co., Muncy, Pa.
Problems concerning size reduction, size classification, mixing, blending, pelleting, densifying, conveying.
H. M. Soars, pres.; H. J. Alsted, v.p. sls.; D. Fisher, ch. engr. 846, 848

Stainless Products Corp., Belding, Mich. 1158

Standard Steel Corp., Los Angeles, Calif. 153

Star Tank and Filter Corp., New York, N. Y.
Filter presses, pilot plant, valves.
M. Burns, proj. & des. engr.; W. Wilkins, fld. engr.; N. R. Burns, pl'nt mgr. 233

Stearns Magnetic Products, Div. of Indiana General Corp., Milwaukee, Wis. 131

Steel and Tubes Div., Republic Steel Corp., Cleveland, Ohio. 68

Steinen Mfg. Co., Wm., Newark, N. J. 1194, 1196

Sterling-Fleischman Co., Broomall, Pa.
Hydraulic drum lift.
M. M. Fleischman, pres. & others. 1077

Sticht Co., Herman H., New York, N. Y.
Tachometers, meas. instruments, stirrers, stop watches. 1280

Stoffel Seals Corp., Tuckahoe, N. Y.
Seals and tags for chem. industry, seals for pharmaceutical and cosmetic products.
J. Betti, E. Walsh, A. A. Colucci. 1257

Stokes Corp., F. J., Philadelphia, Pa. 38, 67

Strahman Valves, Inc., Florham Park, N. J.
Steam valves, level gauges, mixing valves, spray nozzles.
R. Strahman, R. Jaegel. 815

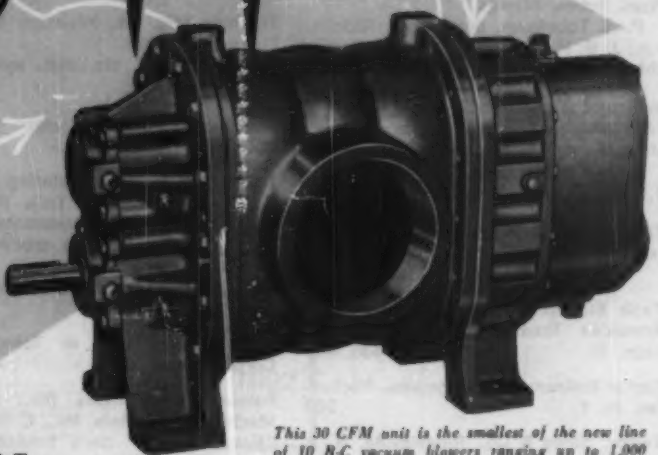
Strong, Carlisle & Hammond, Conneaut, Ohio.
Steam traps, valves, strainers.
H. H. Maltbie, sls. mgr.; O. F. Sutliff, E. Buchholz, P. Cudone. 1121

Strong-Scott Mfg. Co., Minneapolis, Minn.
Mixing equip., pulverizer, blenders.
R. R. Strong, ex. v.p.; R. W. Fredrikson, gen. sls. mgr.; R. Roloff, sls. mgr. 1274, 1276, 1278

continued on page 158

NOW

for efficient vacuum service as low as 30 CFM…



This 30 CFM unit is the smallest of the new line of 10 R-C vacuum blowers ranging up to 1,000 CFM. They bring the total selection of Roots blowers to 46 sizes…with savings for you in every size.

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DIVISION OF DRESSER INDUSTRIES, INC.
1159 Indiana Ave., Connersville, Ind. In Canada—629 Adelaide St., W., Toronto

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CEP CHEM SHOW SPECIAL

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Sturtevant Mill Co., Dorchester, Boston, Mass.
"Micronizer", high-capacity abrasive grinder, "Pulver-Mill", other processing equipment.
C. F. English, ex. v.p. & gen. mgr.; D. J. Sullivan, engr.; R. D. Arnold, sls. engr.; G. J. Traendly, sls. 421

Superior Electric Co., Bristol, Conn.
Transformers, connectors.
J. S. Louden, sls. mgr.; B. Deming, dist. sls. mgr.; C. Downey, sls. engr.; J. P. Bradley, sls. engr. 804

Superior Tube Co., Norristown, Pa. 1200

Supreme Div. Franklin P. Miller & Son, Inc., E. Orange, N. J. 1010

Sutorbilt Corp., Compton, Calif. 446

Swepco Tube Corp., Clifton, N. J.
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P. A. Tobelman, pres.; A. J. Ridella, v.p.; J. G. Harvey, asst. pres.; J. Seme, chf. engr. 834

Syntron Co., Homer City, Pa.
Vibrators, feeders, elevators, packers, shakers, valves, switches.
E. A. Kreuder, v.p.; A. M. Metz, v.p.; J. K. Campbell, J. R. Skelton. 163

Tank Car Div., General American Transportation Corp., Chicago, Ill. 435, 436, 442

Tank Storage Terminals Div. General American Transportation Corp., Chicago, Ill. 435, 436, 442

Taylor Instrument Companies, Rochester, N. Y. 104

Taylor, Stiles & Co., Riegelsville, N. J. 1357

Technicon Controls, Inc. Chauncey, N. Y.
"AutoAnalyzer."
E. C. Whitehead, ex. v.p.; C. R. Roesch, Jr., sls. mgr.; R. D. Goldberg, sls. engr. 316

Tenso-Lab., Inc., Irvington-on-Hudson, N. Y. 1123

Terriss Div., Consolidated Siphon Supply Co., Inc., New York, N. Y. 1329, 1331

Thayer Scale Corp., Pembroke, Mass. 1348, 1350, 1352

Thermo Electric Co., Saddle Brook, N. J
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Thermon Mfg. Co., Houston, Texas.
Thermon, tubing.
W. E. Brown, sls. mgr. asst.; R. L. Burdick, sls. mgr. 1207

Thompson-Ramo-Wooldridge Products Co., Los Angeles, Calif. 13

Titanium Alloy Manufacturing Div., National Lead Co., New York, N. Y.
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D. D. Wheeler, sls. mgr.; H. J. Smith, sls. devel. engr.; R. E. Mullady, sls. devel. engr. 234

Toledo Scale Div. of Toledo Scale Corp., Toledo, Ohio. 157

Tolhurst Centrifugals Div., American Machine and Metals, Inc., E. Moline, Ill.
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R. M. Hames, gen. sls. mgr.; A. J. Schleich, asst. sls. mgr.; W. C. Smith, chief appl. eng.; R. Morton, sls. and others. 506

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Traylor Engineering & Manufacturing Div. of Fuller Co., Allentown, Pa. 495

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Trinity Equipment Corp., Cortland, N. Y.
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G. Baur, R. Hyer, R. Axt, E. M. Feeley, v.p., sls. 1392

Tube Turns Div. of Chemetron Corp., Louisville, Ky. 98

Tube Turns Plastics, Inc., Louisville, Ky. 96

Turbo-Mixer Div., General American Transportation Corp., Chicago, Ill. 435, 436, 442

Tyler Co., W. S., Cleveland, Ohio. 574

Uehling Instrument Co., Paterson, N. J. 364

Union Bag-Camp Paper Corp., New York, N. Y. 1296, 1298

Union Carbide Corp., New York, N. Y. 460, 470

Union Carbide Metals Co., Div. of Union Carbide Corp., New York, N. Y. 460, 470

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Ferranti-Shirley cone-plate viscometer with an automatic program unit and x-y plotter will be shown at Ferranti Electronic's booth.

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Union Steel Corp., Union, N. J.
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H. Lubin, pres.; W. Lubin, genl. mgr. 1085

United States Borax & Chemical Corp., New York, N. Y.
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Industrial motors, vertical solid shaft pump motor, variable speed transmission and integral motor. 837

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U. S. Mixers Div. of Stockdale Eng. Co., Haddonfield, N. J. 1237

United States Steel Corp., Pittsburgh, Pa. 590

United States Stoneware Co., New York, N. Y. 111

Vac-U-Max, Belleville, N. J.
Air-operated, high-suction industrial vacuums, "Jet-Air" pneumatic conveyor system.
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Vanton Pump & Equipment Corp., Div. of Cooper Alloy Corp., Hillside, N. J. 103

Velan Steam Specialties Inc., Plattsburgh, N. Y. 1300

Velan Valve Corp., Plattsurgh, N. Y. 1300

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Vibra screw.
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Wallace & Tiernan Inc., Belleville, N. J.
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S. A. Cole, C. A. Rowe, G. C. White, J. C. Cochrane. 686

Walworth Co., New York, N. Y.
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Wheelabrator Corp., Mishawaka, Ind. 190

Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill. 395

Williams Patent Crusher & Pulverizer Co., St. Louis, Mo. 161

Wilmot Castle Co., Rochester, N. Y.
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W. K. Glen, sls. mgr.; C. R. Meyers, Jr., dist. mgr., N. Y.; A. P. Kretz, Jr., dist. mgr., Chic. 1033

Wolverine Tube Div. of Calumet & Hecla, Inc., Allen Park, Mich. 1111

Worcester Valve Co., Inc., Worcester, Mass. 1163, 1165

Worthington Corp., Harrison, N. J.
Pumps.
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Yarnall-Waring Co., Philadelphia, Pa.
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Yeomans Bros. Co., Melrose Park, Ill.
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BY... Strong Scott

FOR MODERN METHODS AND TECHNIQUES OF MIXING, BLENDING AND PARTICLE SIZE REDUCTION...

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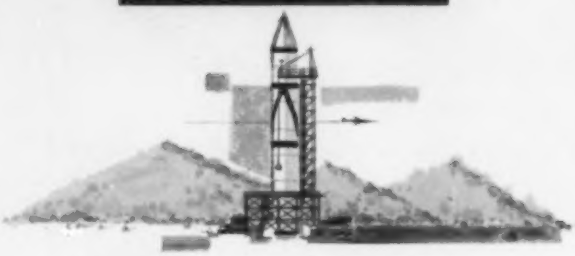

For over 60 years, The Strong-Scott Mfg. Co. has furnished industry with equipment engineered to meet high efficiency processing requirements. The background, experience and ability of our engineers combined with the craftsmanship of our production personnel assure you of well built, well engineered equipment that always delivers top performance. We are proud to have earned this reputation.

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Booths 1274-1276-1278
27th Exposition of
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451 Taft Street N.E., Minneapolis 13, Minnesota

EQUIPMENT DESIGNED FOR BETTER PROCESSING

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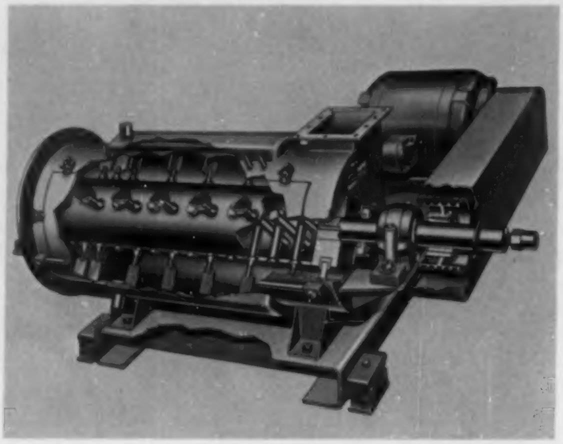

Provides an easy, positive, economical method of intimate dispersion (solids and semi-solids) and kneading (viscous, pasty materials) on a continuous basis. The operating principle, labeled "Turbulizing," combines turbulent, shear and impact action. Special features allow great versatility in application. Angle of paddles and peripheral speed are adjustable to control "Turbulizing" action. Jacketing of mixing chamber plus hollow rotor shaft for heat transfer medium permit control of temperature of ingredients. A hinged cover door, which is an integral part of the mixing shell, provides quick accessibility to chamber. The TURBULIZER is compact for easy installation, clean and dustless for sanitary operation. Available in either 14 or 20 in. shell diameter in portable or stationary designs. Constructed of carbon or stainless steel.

FOR BLENDING...RIBBON BLENDER

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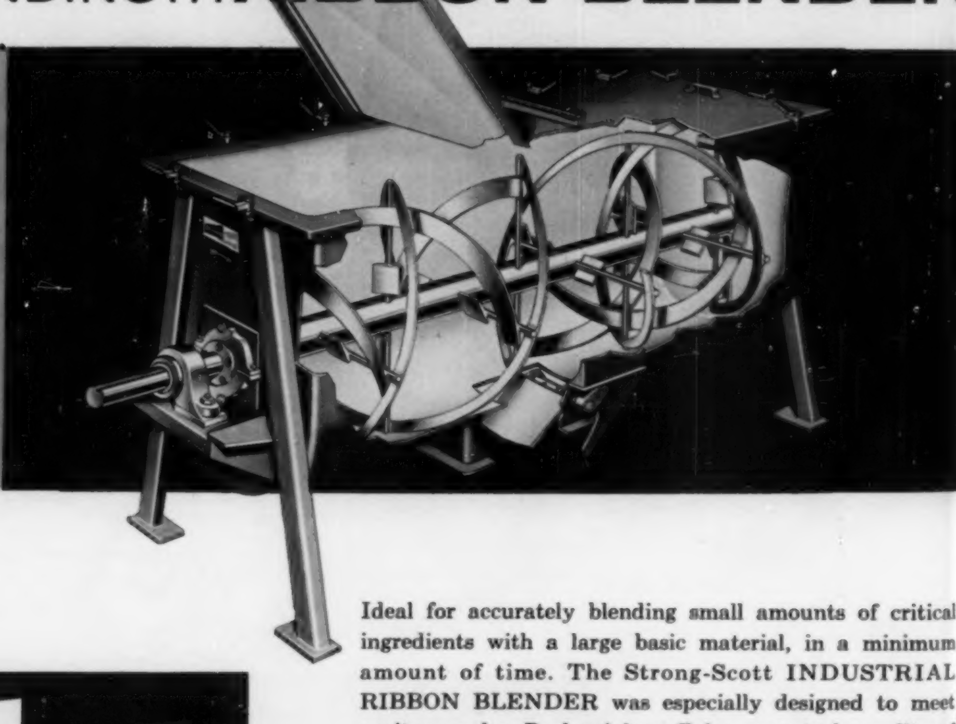

Ideal for accurately blending small amounts of critical ingredients with a large basic material, in a minimum amount of time. The Strong-Scott INDUSTRIAL RIBBON BLENDER was especially designed to meet sanitary codes. Peak mixing efficiency controls quality of product. Simple operation and maintenance requirements lower your production costs. Units available in nine sizes from 16 to 300 cubic foot working capacities. Constructed of either carbon steel or stainless steel.

Strong Scott

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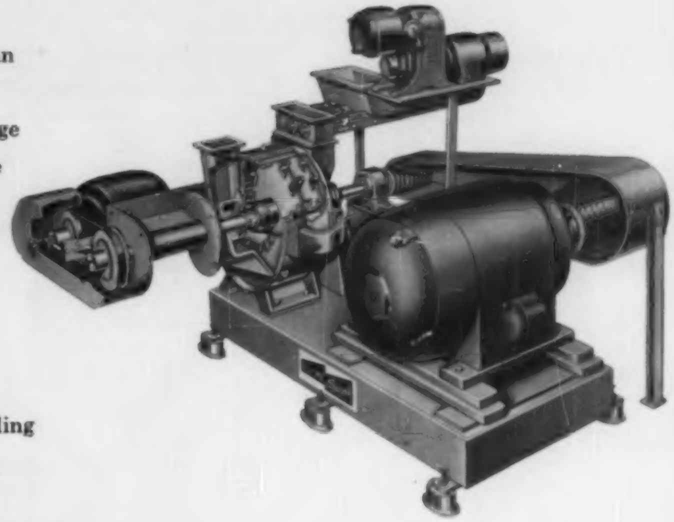
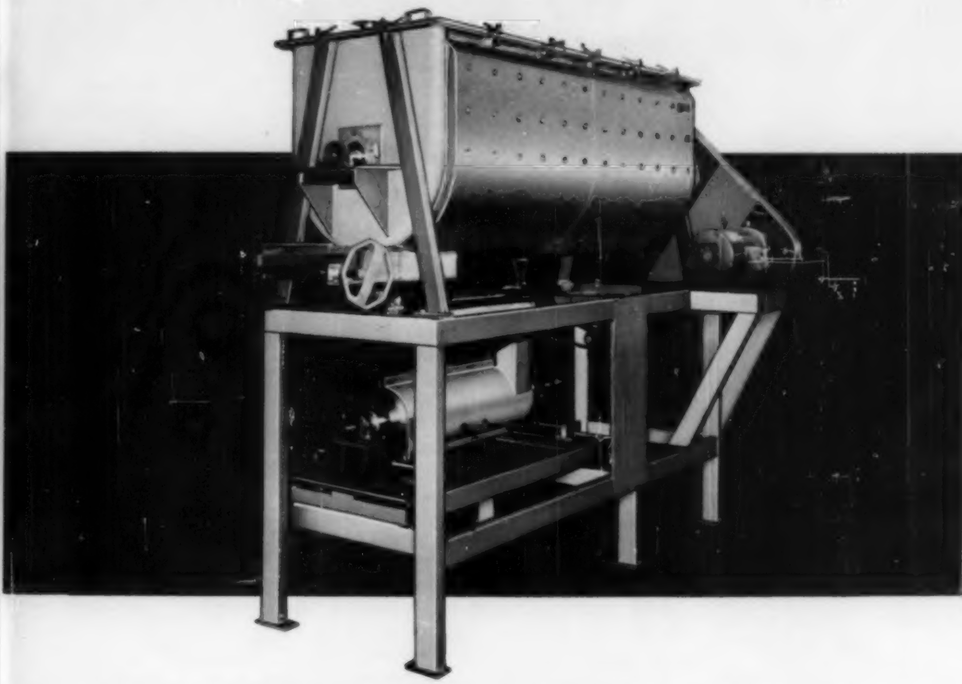
An impact and air attrition pulverizer combined with an integral particle size classifier. Extremely versatile, the PULVOCRON produces a product in the very fine range of 95 to 99% less than 5 to 10 microns, or in the coarse range of 60 mesh. Products that the PULVOCRON will process vary from those of extreme hardness to fluffy softness. The Pulvocron features easily adjusted, particle size control . . . pulverized product temperature control . . . quick accessibility for inspection and sturdy construction for years of service. Available in two sizes—20 in. and 38 in. diameter grinding chamber. Constructed of carbon steel or stainless steel.





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COMBINED UNIT INSTALLATIONS
. . . a customized processing system

Strong-Scott engineers have developed various processing systems to solve particular problems. All Strong-Scott products are designed to function as integral parts of a system so that our engineers can combine various units to perform a particular process. Shown here is a Batch Compounding, Continuous Mixing (BCCM) System, utilizing a Strong-Scott Industrial Ribbon Blender and Turbulizer, that produces the ultimate end product to meet a particular need. Many systems developed by Strong-Scott Engineers are operating now in the process industries. Consult Strong-Scott with your processing problems.

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SARGENT imaginative engineering has created numerous "firsts" that are now standard in many industries . . . better drying equipment and methods for better production and better products at less cost.

The first gas-fired rubber dryer was a Sargent. The first flashless powder was dried in a Sargent. The first gas-fired conveyor dryers for tobacco, for grain, for wool stock, all were Sargents. New man-made textile fibres and innumerable other products have come to the market dried by special-design Sargents that were designed, engineered and built to the exacting needs of product and of production.

From small lab and table models, from tray and truck dryers, through huge capacity, multi section, multi-stage conveyor dryers and rotary dryers, a Sargent is engineered to serve profitably and well for many years to come.

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- in operating economy
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- dependability of guaranteed performance
- fastest installation, with erection costs the lowest on the market

Let us give you details.

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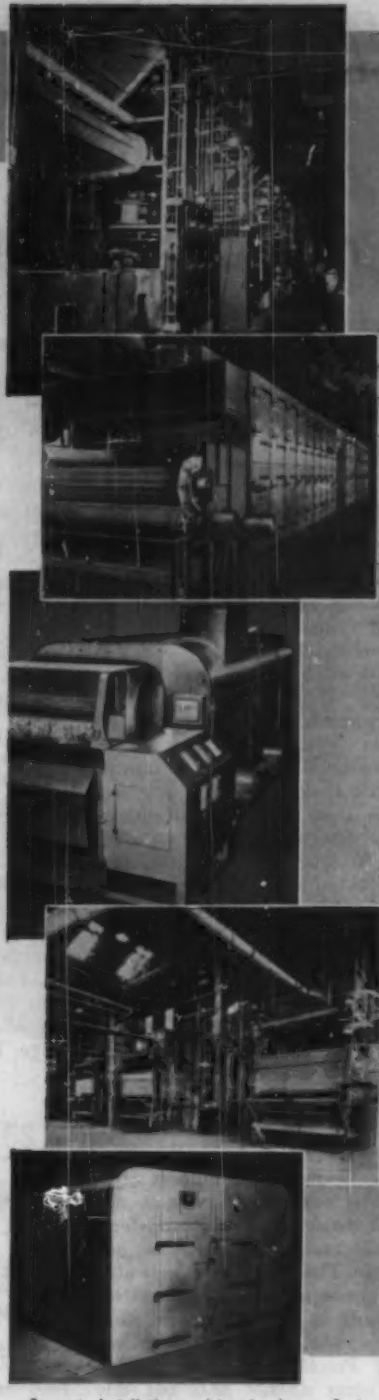

Sargent installations pictured above: Bank of 4 synthetic rubber dryers, 3-pass, gas-fired, at Goodyear Tire and Rubber Company, Houston, Texas • Two-stage Kaolin dryer with Sargent double-hopper extruder, at American Industrial Clays, Sandersville, Ga. • Pilot plant dryer with extruder and cooling sections. Remarkably compact and efficient. At a well-known chemical company • Four Sargent dryers for England's first general purpose (bulk) synthetic rubber plant. Built under Sargent license — installed at International Synthetic Rubber Co., Ltd., Hythe, Southampton • Two-compartment truck dryer with controlled even heat distribution through all trucks, at a large chemical company.

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chemical feature

C. E. Farnsworth and C. W. Virgin
Enjay Co., New York, N. Y.

Properties of polypropylene

Excellent mechanical and chemical properties, high deformation temperature of new plastic promise wide use in chemical processing equipment.

A real economic advantage which polypropylene has over any other type of plastic is shown in Figure 1. This, being the lightest plastic now under commercial development, offers the highest specific volume. While this advantage is marginal in some cases, it is extremely large in others, for example when compared with nylon, the phenolics, or the cellulosics.

For many years, the plastics industry has reported the ultimate tensile and ultimate elongation of a given material. This, of course, leads to very poor design of many parts, particularly in the case of applications where repeated loads are encountered (Figure 2). The use of yield strength

Figure 2. Mechanical properties of polypropylene at 73°F.

Yield strength, psi 2"/min.	5000
Yield elongation, % 2"/min.	15
Impact strength, ft. lb./in.	
Izod notched	1
Izod unnotched	16
Stiffness in flexure, psi	110,000

and yield elongation is more indicative of the potential usefulness of a plastic. The data shown indicate the excellent strength of polypropylene insofar as tensile considerations are concerned. The figure also indicates that the material is notch sensitive, which leads to the recommendation that sharp radii be avoided wherever possible. Practical tests on various molded items do not bear out this low notched Izod figure. The high yield strength of polypropylene comes to the fore before the ultimate notched impact strength. The stiffness of any given plastic must be measured in a number of different ways to be meaningful to the design engineer.

Prolypropylene's good surface hardness and abrasion resistance (Figure 3) have suggested its application in many low-load bearing applications. There are many places for which it will be very useful at low cost, where the ultimate in abrasion resistance is not needed. Polypropylene's high melting point and its high temperature before it deforms under load make it extremely useful in relatively high-temperature applications: that is,

Figure 3. Properties of polypropylene.

Hardness Rockwell R, at 73°F.	90
Taber abrasion, mg. loss/1000 cycles (CS-17 wheel, 1000 g. load) at 73°F.	30
Melting point, °F.	335
Deformation under load	
°F. at 66 psi	188
°F. at 264 psi	131

relative to any except the very highest-priced thermoplastics. Preliminary data indicate that polypropylene maintains its high yield strength well up towards the top of its temperature range. This, of course, extends its usefulness in engineering applications.

It should be noted here that this material exhibits an outstanding recovery to its original shape after being deformed.

Polypropylene is exceptionally inert, and therefore displays excellent chemical resistance. The resistance to various materials which might possibly be encountered around a refinery are shown in the next three figures. In Figure 4 is shown resistance to a variety of oxygenated materials, most of which are common solvents. In Figure 5 is shown polypropylene's resistance to some typical hydrocarbon materials, and in Figure 6 its resistance to a variety of inorganic salts, acids, and bases.

Environmental stress-cracking is the term used to designate the tendency of certain plastic materials to lose physical properties when stressed in

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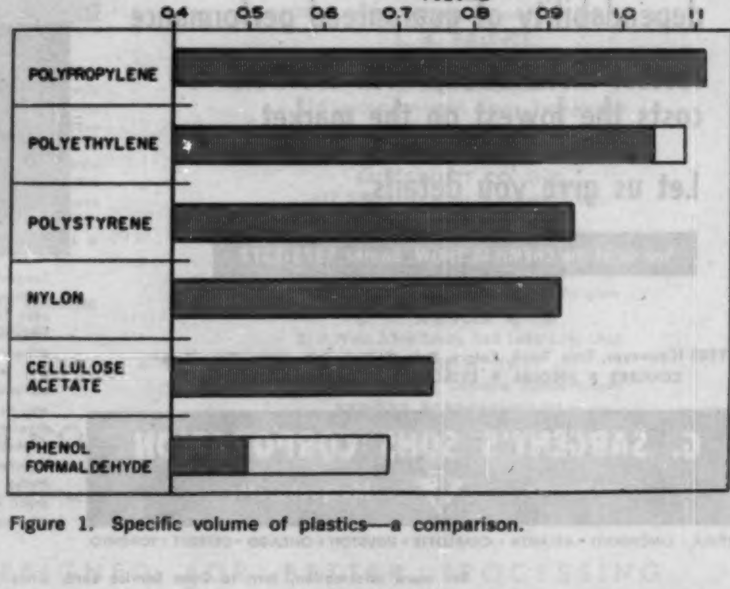

Figure 1. Specific volume of plastics—a comparison.

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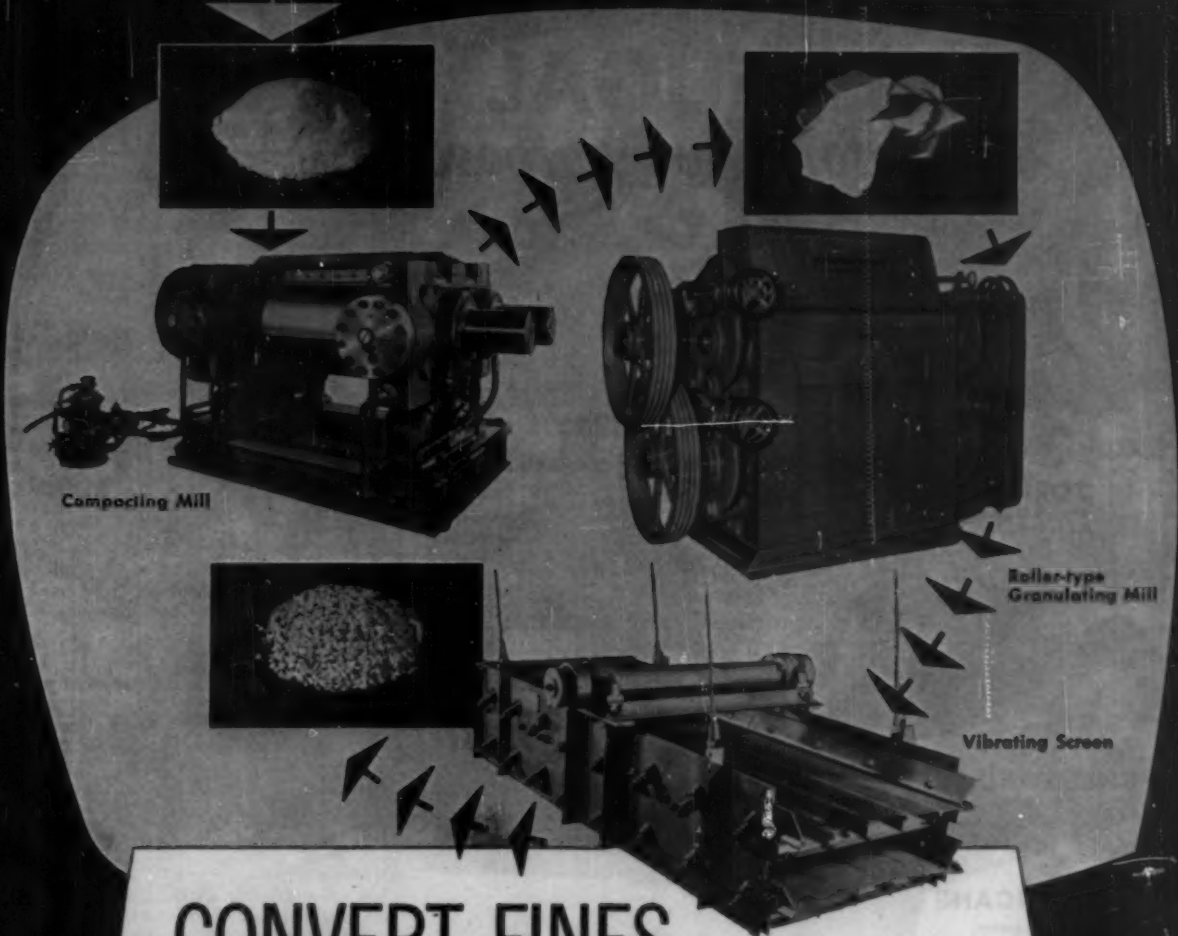
ALLIS-CHALMERS



CONVERT FINES

to high-quality granules with a complete processing circuit

The Allis-Chalmers compacting process can turn 80 to 90% of your present waste fines into salable granules . . . often of higher quality than the granules produced in your original process. For example: Tests on products reconstituted by the Allis-Chalmers system have shown compacted granules to have better controlled solubility, more uniform particle size, better "eye-appeal" and freer flow.

Here's how fines are recovered: Waste or fine salts from the original process are fed into a compacting mill. The mill mechanically densifies the fines into flakes. Flakes are then granulated by a roller mill—separated and sized by a vibrating screen.

For more information, get Bulletin 07B8836 from your A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

A-C ALLIS-CHALMERS

A-1191-C

chemicals

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the presence of certain polar materials. This is a particularly insidious deficiency with certain plastics, because often it does not become apparent until an article has been in service for some time. Polypropylene shows no tendency to stress-crack in the presence of any of the polar materials tested to date.

Polypropylene can be fabricated by any of the techniques common to the

Figure 4. Chemical resistance of polypropylene.

	Effect after impression for 1 week 73°F	150°F
Acetone	nil	slight
Methyl ethyl ketone	nil	slight
Isopropyl alcohol	nil	nil
Methanol	nil	nil
Phenol solution (5%)	nil	nil

nil—negligible effect.
slight—function of part unimpaired.

Figure 5. Chemical resistance of polypropylene

	Effect after immersion for 1 week 73°F	150°F
Benzene	slight	n. s.
Gasoline	nil	resistant
Hexane	nil	slight
Toluene	slight	n. s.
Motor oil	nil	resistant

nil—negligible effect.
slight—function of part unimpaired.
resistant—satisfactory for some applications. Recommend testing before use.
n. s.—Not suitable.

plastics industry. The very high luster of polypropylene's molded surface is of particular interest to consumer-goods manufacturers.

Polypropylene may be extruded into heavy-gauge sheeting for tank linings, fume hoods, and duct work. It may also be extruded into pipe for service with fresh or salt water, corrosive chemicals, air instrumentation, or crude-gathering lines. In addition, extruded pipe coatings or linings are being tested to improve the service life of conventional metal pipes in rigorous service. It should be noted that polypropylene's high-luster finish will greatly reduce the frictional losses usually encountered in metal pipe.

Extruded thin films of polypropylene are now being tested for oil packaging. Such film, of almost any de-

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For more information, turn to Data Service card, circle No. 55

chemicals

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sired width, should also find industrial uses as tarpaulins for temporary coverings during construction or as permanent moisture vapor barriers.

Extruded profiles are being considered for gaskets, oil seals, decorative trim, and weather seals. Because of its outstanding electrical properties, communication wire insulated with polypropylene is now under test.

Figure 6. Chemical resistance of polypropylene.

	Effect after immersion for 1 week	
	73°F	150°F
Hydrochloric acid, 35%	nil	nil
Nitric acid	nil	resistant
Sodium chloride, 10%	nil	nil
Sodium hydroxide, 40%	nil	nil
Sulfuric acid, 98%	nil	resistant

nil—negligible effect.
resistant—satisfactory for some applications. Recommend testing before use.

A newly completed vinyl emulsion polymerization plant just put on stream in Toronto by National Starch and Chemical (Canada) Ltd. The National Starch and Chemical subsidiary will produce vinyl copolymers and homopolymers in emulsion form. Production will be used both internally for the manufacture of adhesives, and for sales throughout Canada to manufacturers in the paint, paper coating, textile, and allied fields.

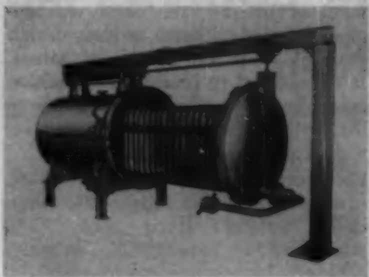
A 30,000 metric ton per year ethylene plant just placed on stream by Montecatini is the company's second in Ferrara, Italy. The plant is also designed to produce 15,000 metric tons annually of high purity propylene. This will go into the production of isotactic polypropylene plastics, fibers and elastomers.

Construction of a phthalic anhydride plant in Switzerland is part of Reichhold Chemicals' $5 million expansion at their facility in Hausen bei Brugg. The new plant, built by Reichhold Chemie, Swiss affiliate of the parent firm, has a capacity of 10,000 tons annually, is scheduled to go on stream early in 1960.

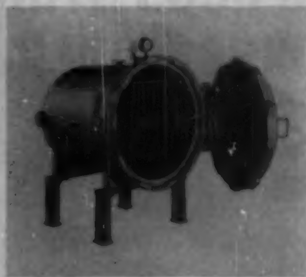
A new CM-2 Analog Computer will be used for efficiency calculation on pilot plant operations at Dow Chemical's Freeport, Texas, plant. The computer was acquired from SIE (Dresser Industries).

PROCESS FILTERS

Process-Bowser Filters offer broad range fulfillment of process industry needs, utilizing all types of filter media. Available in special alloy tank materials and fittings. Control instrumentation for manual operation or any degree of automation.



MODEL H units to 2000 sq. ft. provide capacities for large processing plants.



MODEL HS units to 400 sq. ft. meet most batch recovery needs.

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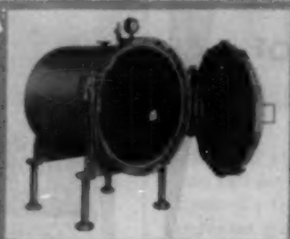

A 40 sq. ft. Model HL is capable of doing a job in less time than most filters double its size. One-man cleanout access speeds residue removal for added time savings and attendant operating economy.

MODEL HL FEATURES

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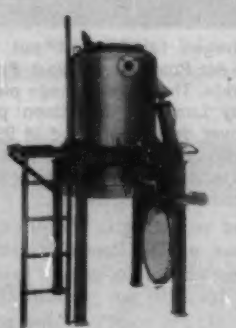
- Availability with choice of several filter media.
- Application-engineered variables to meet requirements.



MODEL VB units to 600 sq. ft. include bottom drop feature for heavy cake unloading.

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chemicals

Current U.S. production of helium has been increased by 65 per cent, with the completion of a $10 million helium recovery plant near Boise City, Oklahoma. Located in the Keyes natural gas field, the plant was designed to extract helium from more than 50 million cubic feet of natural gas per day. Built by Fluor for the Department of Interior, the plant was engineered with a basic process design developed by the Bureau of Mines. It is expected to produce 300 million cubic feet annually of crude helium for further refinement in Bureau installed equipment.

Construction of a phosphoric acid plant, the first unit of a multi-million dollar fertilizer facility, has been started by the Bunker Hill Company, Kellogg, Idaho. Starting capacity of the unit will be 130 tons a day, with provision for additional facilities. Bunker Hill's zinc plant, will provide sulfuric acid, a by-product for production.

Liquid hydrogen facility just put on stream for Air Products at West Palm Beach, Florida. The large tonnage plant designed by Lummus, has been producing at over design rate and at 99+ purity. Hydrogen production section combines Florida crude oil oxygen and water to produce hydrogen gas.

A one third reduction in the price of "Viton", one of Du Pont's synthetic rubbers, just put into effect, brings the price to $10 per pound. The fluorine-containing elastomer has seen increasing use for aircraft and missile applications where ability to perform in temperatures up to 600 degrees F. is desirable.

A polystyrene and vinylidene chloride copolymer manufacturing plant will be built in France jointly by Dow Chemical International and Pechiney S.A. Start-up is scheduled for 1961. The new plant site is at Ribecourt, near Paris, where Pechiney operates a polystyrene manufacturing facility. The Styron, and Saran, Dow's trade name for the products, will be marketed in France.

equipment feature

T. Kirby and J. Feorino,
Metal & Thermit Corp., Rahway, N.J.

"Lamp-shade" filter increases efficiency of batch decantation washing.

Special design installed on suction end of decant leg said to have reduced number of washes from twelve to four.

Batch decantation washing often has application in the process industries on smaller tonnage chemicals when a high degree of freedom from soluble contaminants is desired. This high purity is not always obtainable by a displacement wash on a filter press. Batch decantation washing involves addition of wash water, agitation of the slurry, settling, and decantation of the supernatant liquid.

Various types of filter leaves have been used in decantation operations. The purpose of the filter leaf is to increase the fraction of water removed without incurring any loss of product. Filter leaves employ a vertical contact section which, to function, must be completely submerged (Figure 4). Once any section of the filter screen is exposed to the atmosphere, the prime is lost and the decantation ceases. Therefore, with a vertical contact section, a layer of water equal to the height of the filter screen will always be left in the decantation vessel. On the other hand, the filter developed for the use with the crystalline material in question utilizes a horizontal filter screen (Figure 3). Since only horizontal surface contact is necessary to keep the decant leg functioning, this "lamp shade" filter can be used to suck the material to virtual dryness.

The quantative effect of increasing the fraction of water removed can be derived from Equation I.

1. $YN/YO = (1-F)N$*

YO = soluble impurity present initially
YN = soluble impurity present after decantation N
F = fraction of water removed per decantation
N = number of washes

One implication of this equation not pursued in the reference article is the variation of N with F. A plot of N vs. F can best be obtained as follows: Take the natural log of both sides of equation 1.

2. $\ln YN/YO = N \ln (1-F)$

For any given purity desired in the final product, YN/YO is constant and ln YN/YO is constant. Equation 2 can be arranged to read:

3. $K/N = \ln (1-F)$

Equation 3 is plotted on semi-log paper with l/N on the linear coordinate and (1—F) on the log coordinate to yield a straight line (Figure 1).

From Figure 1, any number of values can be read off and easily converted to N and F to give coordinates

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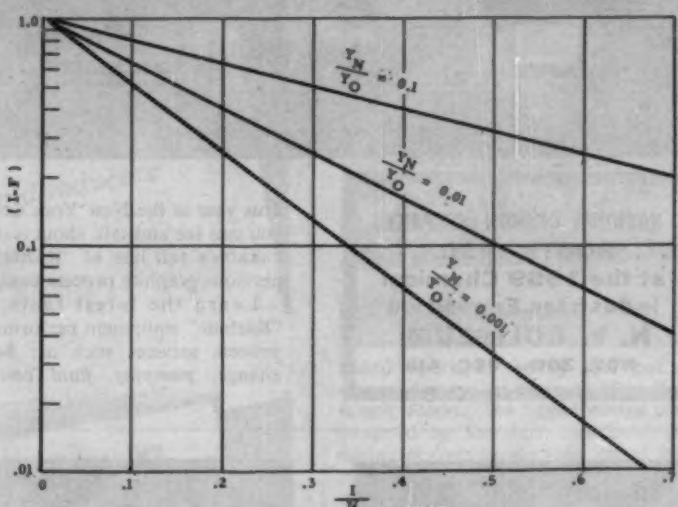


Figure 1. Plot of (1-F) vs. 1/N for varying values of YN/YO (Eq. 3).

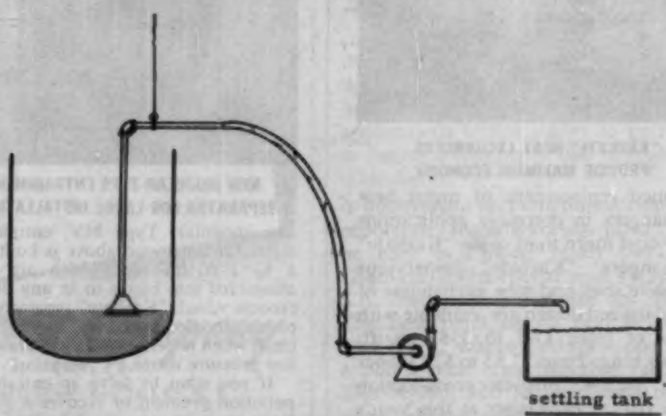
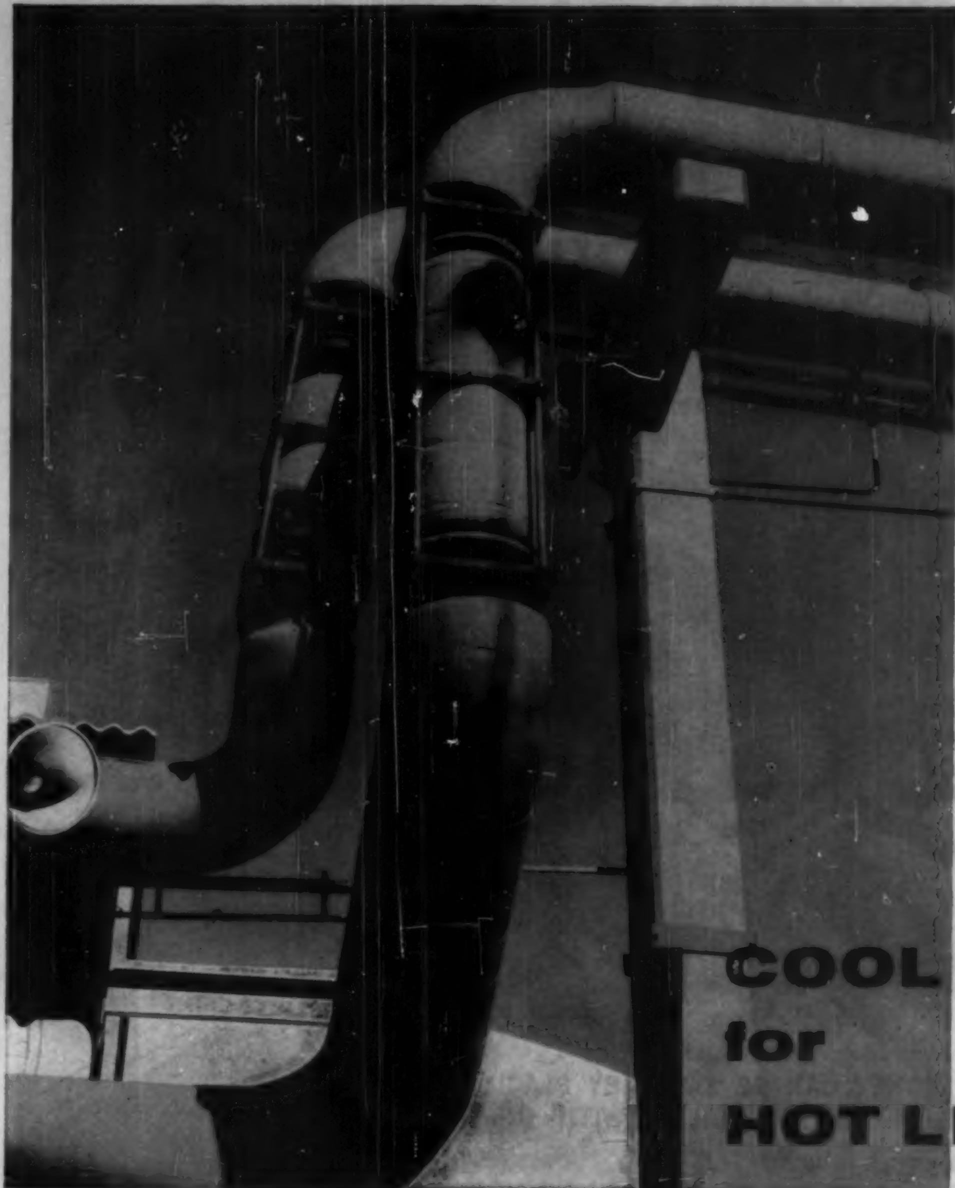


Figure 5. Use of lamp-shade filter in decantation washing.

* *Chem. Eng.*, April 20, 1959, pp 169-170



Batch decantation

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for a plot of N vs. F on linear paper (Figure 2).

Figure 2 shows that N increases sharply as F decreases, particularly in the lower range of F. For a YN/YO of .01, meaning that about 99% of the soluble impurity must be removed, an F of .4 will require 9

Figure 3. "Lamp-shade" filter.

washes, whereas an F of .9 will require only 2 washes.

With this crystalline material, F was increased in the following manner: The "lamp shade" filter pictured

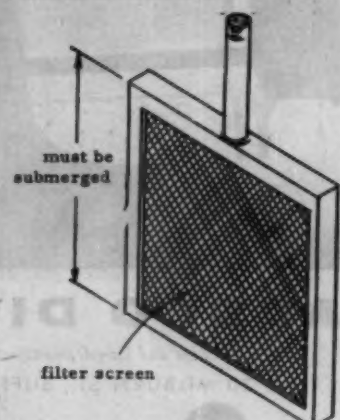

Figure 4. "Flat" filter.

in Figure 3 was attached to the suction end of a decant leg. The decant leg was connected to a centrifugal pump which discharged into a settling tank. The settling tank was used as insurance in case any solids came through the screen (Figure 5). The solids were allowed to settle in the decantation vessel for five minutes,

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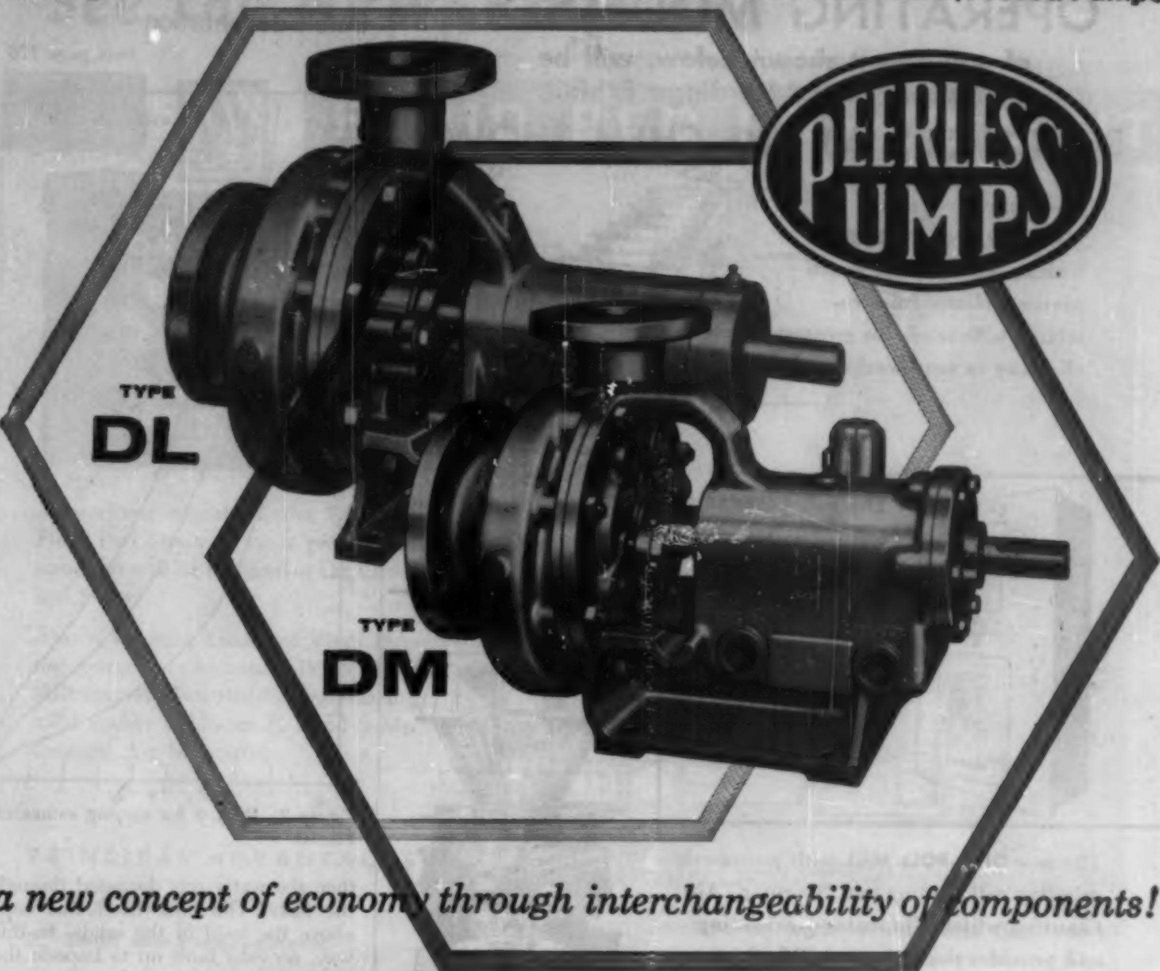

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Batch decantation

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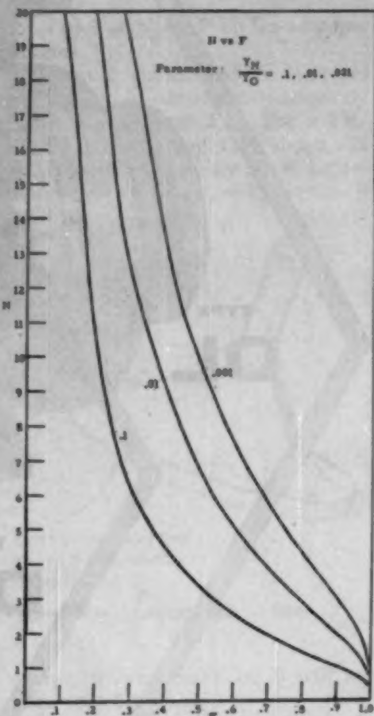

Figure 2. N vs. F for varying values of YN/YO.

then the water was decanted through the filter. The filter head was kept above the level of the solids. In this way, no cake built up to impede the decantation rate.

When the supernatant liquid had been decanted, the filter was lowered into the solids and the decantation continued without interruption. With the filter head in the solids, the rate of decantation decreased slightly. As more water was removed from the solids, the filter head was lowered to the bottom of the vessel and the decantation was continued until the prime to the pump was broken.

This same method was tried without success on a material made of small, soft crystals. The fines in this slurry tended to clog the filter pores, slowing the rate to almost nil. For this method to be applicable, the solids being washed should be relatively easily filterable.

One assumption of Equation 1 is that there is no co-precipitation of impurities with the product. The usual method of removing co-precipitated impurities, whether they be adsorbed or occluded, is by digestion. Digestion is most effective when there is

continued on page 180

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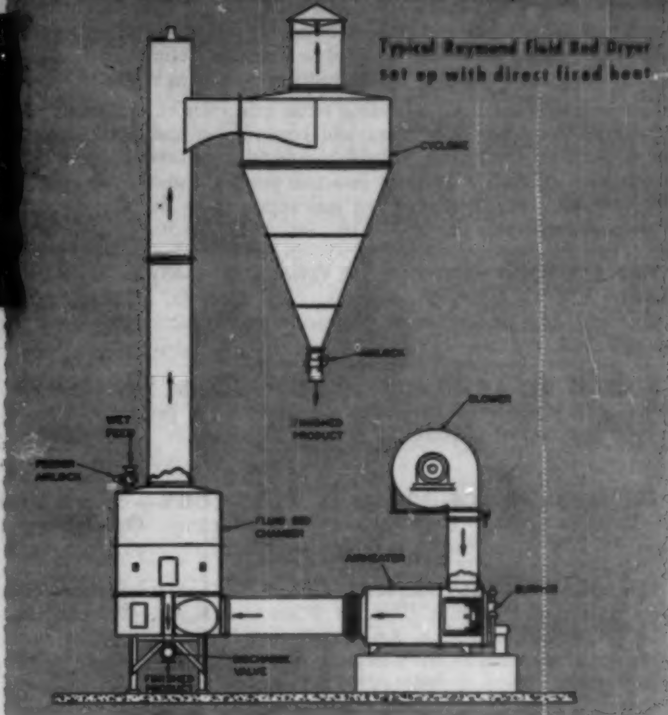

A working model of the Raymond Fluid Bed Dryer in clear plastic construction will be featured at the Chemical Show.

Also a working model of Flash Drying System . . . an actual 18" Vertical Mill specially adapted for pulverizing solid rocket oxidizers . . . and a Mechanical Air Separator.

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3. **Absolute minimum of moving parts (none in high temperature zone) helps to reduce maintenance**
4. **Gentle handling gives minimum degradation**
5. **Permits some degree of particle size classification**
6. **Accurate control of final H_2O**
7. **Continuous, automatic, dust-free operation**

Raymond started development work on the Fluid Bed type of dryer in 1950 as a complement to the well known line of Flash Drying Systems.

This broadened the range of dryers for handling problems where a very minimum of crystal breakage is required, as well as in processes where appreciable retention time is desired.

The first commercial size Raymond Fluid Bed Dryer was installed in 1953 on a problem requiring minimum crystal breakage. Since then, additional units have been installed by themselves or in conjunction with Flash Drying Systems.

Salt, gilsonite, synthetic resins and organic crystals are being handled in these units. Successful test work has been conducted on a variety of other materials.

With the broadened line of drying units now available, it is even more important to consult Raymond engineers when your drying problems come up. A Raymond Fluid Bed or a Flash Dryer could well be the best solution to your problem.

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For more information, turn to Data Service card, circle No. 4

Batch decantation

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a low concentration of the co-precipitated impurity in the water, since then the concentration gradient is high for the mass transfer required. It is, therefore, advantageous to use this method of washing to quickly lower the concentration of the impurity in the water, whether or not there is co-precipitation.

It should be noted that a somewhat slower rate of decantation, once the filter is in the solids, does not indicate failure of the method. The rate can slow down considerably and time still be saved on the over-all washing operation.

Expansion in Polyethylene production

Expansion in polyethylene capacity goes ahead at Union Carbide, with plans for production increases both in the United States and in Italy.

Original plans for a 30 million tons annually polyethylene plant in Sicily have been changed to double that amount. S.p.A. Selene, Sicilian company jointly owned by Union Carbide and Societa Edison, Milan, Italy, will put the original unit in Priolo, Sicily, into operation at the end of this year.

On the domestic front, latest addition to polyethylene production went on-stream with the completion of an 80 million pound per year unit at Carbide's plant at Whiting, Indiana. This brings the company's total capacity for low density polyethylene to over 400 million pounds per year. Market for increased production will go to polyethylene users throughout the midwest.

Expansion just completed at Strahman Valves includes a move from New York City to a new plant at Florham Park, New Jersey. Increased equipment and space, and facilities for further expansion in research, design and development, have been provided. Strahman makes valves, mixing units, nozzles, and level gauges for chemical and other industries.

In India, a company is being set up for the production of sulfur, sulfuric acid and fertilizers. Location is Majore, Shahbad district of Bihar. National Industrial Development Corp. has formed a subsidiary firm to handle production.

 Prepared by U.S.Industrial Chemicals Co.

U.S.I. CHEMICAL NEWS

Nov. ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1959

Ralph Knight Appointed U.S.I. Vice President

Ralph M. Knight, Manager of Polyolefin Planning for U.S.I., was recently appointed a Vice President. In his new position, Mr. Knight will intensify U.S.I.'s long-range polyolefin development program. He will continue to direct the Polymer Service Laboratory as well as to coordinate its efforts with other plastics activities within the company.

The newly created post is a reflection of the expanding role of polyolefin plastics in U.S.I.'s long-range growth plans. U.S.I. is currently the country's third largest producer of polyethylene, which it markets under the trade name PETROTHENE®. The company has underway an extensive expansion program which is expected to make it the second largest producer of polyethylene in the world by mid-1960.

Since joining the company in 1953, Mr. Knight has served as Polyethylene Manager, Polyethylene Production Manager, Assistant to the Vice President for Production, and Manager of Polyolefin Planning.

Chlorine Data Sheet Now Available from U.S.I.

Properties, shipping information and uses for liquid chlorine are detailed in a new data sheet just issued by U.S.I. Complete references for property data are included.

The material, which U.S.I. ships in 30-ton and 55-ton tankcars from Huntsville, Alabama, is used primarily in the bleaching of

MORE

Comprehensive Study Provides Data on Corrosion Resistance of Commercial Titanium-Base Alloys

Alloys Generally Corrode More Than Commercially Pure Titanium

An intensive research program to determine the corrosion resistance of seven of the most commonly used titanium alloys has recently been completed. Results indicate that in strong acids such as sulfuric and hydrochloric, the alloys generally have less corrosion resistance than commercially pure titanium itself. One exception—an alloy containing about 3% aluminum and 2.5% vanadium—has about the same degree of corrosion resistance as the unalloyed metal.

All seven alloys are reported to be completely resistant to solutions of ferric chloride, sodium chloride and sodium hydroxide and, with very few exceptions, to formic acid—under test conditions. Test results in aluminum chloride solutions were very erratic. However, they do indicate that under some conditions, these solutions can attack both titanium and its alloys very severely. In oxalic acid, all alloys corrode excessively.

The program revealed that polished surfaces are more corrosion resistant than pickled-finish surfaces, and that a high dissolved oxygen content in acid solutions slows corrosive action on both the metal and its alloys. The alloys tested, and their chemical analyses, are shown in table 2.

They were immersed for 336 hours in the following corrodents at 95°F. and/or 190°F.: 1, 3 and 5% hydrochloric acid, 5% sulfuric acid, 5% oxalic acid, 25% formic acid, 25% aluminum chloride, 25% ferric chloride, saturated sodium chloride and 25% sodium hydroxide. Studies were made without agitation of the corrosive solution, with air agita-

MORE

Methionine Indicated for Schizophrenia Treatment

Russian researchers have made a preliminary study which indicates that the sulfur amino acid, methionine, has a therapeutic effect in the treatment of schizophrenics. The treatment seems to give best results in the early stages of the illness.

The study was made with 20 patients, eight of whom had been ill for only a short time, with the disease in an acute form. The others had been afflicted for a long period. Methionine treatment was beneficial and helped normalize conditional and absolute reflex activity. In some cases the return of normal vascular reflexes preceded clinical improvements. Blood studies showed sharp changes in the index of thymol reaction and glutamine content of the serum after methionine treatment. The researchers analyzed the urine of the patients and confirmed improved nitrogen metabolism when methionine was administered.

It was noticed that patients become more communicative after treatment. Their appetite and sleep improved, along with their ability to take care of themselves. Psychopathological symptoms leveled off.

TABLE 1.

ALLOY	CORROSION RATES, mpy														
	190°F					95°F									
	NO AGITATION					AIR AGITATION					N_2 AGITATION				
	1% HCl	3% HCl	5% H_2SO_4	5% Oxalic	25% Formic **	3% HCl	5% HCl	5% H_2SO_4	5% Oxalic	25% Formic **	3% HCl	5% HCl	5% H_2SO_4	5% Oxalic	25% Formic **
Comm. Pure Ti—75 BHN	0.10	142	452	—	E	0.07	*	55.6	—	E	4.9	16.1	16.4	—	E
Comm. Pure Ti—120 BHN	3.3	140	254	1158	E	0.17	*	*	38.4	E	5.2	8.2	20.0	52.0	E
Comm. Pure Ti—180 BHN	0.17	196	571	705	E	0.03	*	9.96	20.7	E	5.1	10.4	17.5	32.7	E
Comm. Pure Ti—200 BHN	6.10	216	560	801	E	0.07	*	8.4	14.0	E	6.4	11.1	31.1	32.7	E
MST 8 Mn, Annealed	0.29	233	877	583	E	0.13	28.6	17.0	47.9	E	9.24	17.9	41.9	82.7	5
MST 6 Al-4V, Annealed	59.5	257	872	1582	164	1.35	31.8	44.8	41.9	E	12.4	18.7	32.4	42.8	5
MST 6 Al-4V, Age Hardened	49.4	378	850	983	164	4.05	26.6	26.9	25.7	E	7.97	16.2	29.8	61.9	5
MST 5 Al-2.5 Sn, Annealed	83.2	588	1230	1877	E	13.7	36.6	43.7	57.1	E	22.8	38.5	52.9	43.4	E
MST 821, Annealed	1.46	313	646	1418	E	0.46	14.7	37.2	54.4	E	9.85	15.6	23.7	62.2	E
MST 2.5 Al-16V, Solution Treated	3.4	160	591	561	50	0.49	5.2	0.65	23.8	E	5.47	9.8	21.4	20.2	E
MST 2.5 Al-16V, Age Hardened	3.7	211	660	988	50	0.23	14.2	24.0	22.6	E	9.11	17.6	38.0	20.6	E
MST 185, Annealed	37	430	888	582	E	0.06	*	*	21.8	E	12.9	19.8	43.5	19.0	E
MST 185, Age Hardened	74	450	946	1039	E	0.33	*	*	33.5	E	14.6	22.3	45.5	40.3	E
MST 3 Al-2.5V, Annealed	0.30	147	667	1028	E	0.10	0.05	*	23.1	E	5.01	7.43	16.4	24.8	E

* results erratic ** no tabular data except as shown. E indicates complete resistance.

Nov. ★ **U.S.I. CHEMICAL NEWS** ★ 1959

CONTINUED *Chlorine*

pulp and paper, in the manufacture of chlorinated solvents, in making plastics, resins, automotive fluids, insecticides, herbicides, refrigerants, propellants, and in water and sewage treatment.

The data sheet can be obtained from U.S.I. sales offices or from the Chlorine and Caustic Soda Sales Department, 99 Park Avenue, New York.

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CONTINUED *Titanium Alloys*

tion and with nitrogen agitation.

Actual corrosion rates in mils per year (mpy) are shown in table 1. The following ratings permit interpretation of these mil-per-year figures:

Corrosion rate, mpy	*Rating*
less than 0.5	Excellent
0.5 to 5.0	Good
5.0 to 10.0	Fair
more than 10.0	Poor

The alloys rated about as follows in the tests, starting with the most highly corrosion resistant:

(1) MST 3A1-2.5V
(2) MST 2.5A1-16V
(3) MST 8A1-2Cb-1Ta (821)
(4) MST 1A1-8V-5Fe (185), MST 8 Mn, MST 6A1-4V
(5) MST 5A1-2.5Sn

New Synthetic Ketone With Fresh, Leafy Odor Gives Soap Perfumer New Tool

A new synthetic aromatic ketone, related in activity to a group of trace constituents of essential oils, has recently been discovered and found to possess the soap-scenting effectiveness usually associated with natural materials. Thus the new synthetic material is reported to give the perfumer a new tool for achieving lasting, strong, stable and fragrant soap perfumes with increasing independence from the essential oils.

Although the characteristic, fresh, leafy note of the ketone is not new—an almost identical note being found in petitgrain oil—the new ketone is said to offer many possibilities for original perfumes not possible with petitgrain oil itself. This because it is a concentrated note free from terpene and other ester components that would hamper its adaptability. The material is offered for use by the soap perfumer in petitgrain, bergamot, lavender, vetiver, lemon, neroli and geranium type compositions.

Tests were performed with the new ketone in soap bars and powders, and liquid and powdered detergents. In all cases, the material was reported to give a strong fragrance which lasted, unchanged as to strength and character, through accelerated aging tests.

When incorporated into soap bouquets, the ketone is reported to contribute these advantages to soap cake fragrance: cakes retained their fresh note long after identical cakes without the ketone became flat and lifeless; cakes gave a more diffusive fragrance than identical cakes without the ketone; cakes containing the ketone were judged to have a more refreshing and exhilarating scent.

TABLE 2: CHEMICAL ANALYSES OF TITANIUM ALLOYS USED IN CORROSION TESTS

ALLOY	% O_2	% N_2	% C	% H_2	% Fe	% Al	% V	% Mn	% Cb	% Ta	% Sn
MST 8Mn	0.097	0.01	0.04	0.0082	0.13	..	..	8.2	..	..	..
MST 6Al–4V	0.050	0.011	0.04	0.0031	0.20	6.27	4.21	..	..	..	..
MST 5Al–2.5Sn	0.142	0.03	0.02	0.0032	0.19	5.00	..	..	..	..	[illegible]
MST 821	0.101	0.015	0.02	0.0042	0.26	7.96	..	..	2.26	1.01	
MST 2.5Al–16V	0.093	0.015	0.04	0.0130	0.20	2.65	15.94	..	..	..	
MST 185	..	0.004	0.02	0.0064	5.09	1.76	7.28	..	..	..	
MST 3Al–2.5V	0.120	0.011	0.06	0.0020	0.17	2.91	2.45	..	..	..	

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U.S.I.

Glycerine properties, reactions, performance are covered in new 20-page booklet now available. Describes all commercial grades and types; includes information on storage, shipping, handling; covers variety of known uses. **No. 1530**

Pilot scale versions of two commercial continuous centrifuges can now be obtained for clarifying, separating and concentrating in lab and pilot plant. One unit is for liquids with up to 20% solids, the other for up to 5% solids. **No. 1531**

Montmorillonite catalysts, made from bentonite and aluminum hydrosilicate and used mainly in reactions otherwise catalyzed with hydrogen acids, are now marketed in U.S. Characterized by highly selective catalytic activity. **No. 1532**

New type applicator for ether aerosol diesel starting fluid has been developed. Holds standard aerosol can and feeds fluid into intake manifold of engine through closed system. Said to give quick start without fluid waste of vapor escape. Is compact, fits any engine. **No. 1533**

New guide for fire and explosion prevention in plants producing and handling zirconium can now be purchased. Pamphlet outlines safeguards for fire prevention, dust collection, fire protection, and disposal of waste materials. **No. 1534**

Skin lotion to keep hands free from drying by solvents has been developed for use by chemists and clinicians working with acetone, methanol, ether, alcohol, xylene, benzene, chloroform, detergents, alkalis, etc. **No. 1535**

New facepiece for gas and hose masks, air line respirators, demand breathing apparatus, is now on market. Features easily replaceable, large single lens, improved speaking diaphragm, built-in accommodation for glasses, no fogging. **No. 1536**

Acid inhibitor has been made odorless, without changing inhibiting properties of product. Material is added in small amounts to acid pickling solutions to prevent attack of steel and copper, and reduce rust during steel drying. **No. 1537**

Laboratory production and use of sodium wire are outlined in new technical data sheet. Includes photo, diagrams, complete description of equipment; extrusion method; typical reaction of the wire in Bouveault-Blanc reduction. **No. 1538**

New Product for poison ivy treatment is said to act quickly by neutralizing ivy phenols which cause rash and itch. Works on ion exchange principle to convert toxic phenolic compounds to inactive phenolates. **No. 1539**

Management of new product development

"Management's first responsibility is the production of profits," declared L. A. Hatch of Minnesota Mining and Manufacturing, opening a recent panel discussion* at A.I.Ch.E.'s national meeting in St. Paul with a talk on management's role in new product development.

There is at present, according to Hatch, a challenging future in upper management for chemical engineers who are motivated in the direction of business development, and who are equipped with an engineering education, an "adequate" intellect, ambition, and personality. However, he went on to point out, these men must learn now to do field engineering in order to determine the customer's point of view and his needs. They must become capable of reducing an idea from the research phase to practice, and of solving the problems of pilot and semi-works operations. These requirements demand, in general, a minimum of three years of hard "on-the-job" training.

After the chemical engineer has become competent in all of these new areas, or a specialist in one of them, he must add a working understanding of the company's capital investment and operating policies, the business implications of different kinds of patents, corporate legal problems, interdepartmental relationships, and, above all, the importance and difficulty of "getting a million dollar's worth of orders from satisfied customers at a profitable price."

The importance of communications as sources of ideas was stressed by W. E. Kuhn of Texaco, who continued the session with a consideration of the question—*Who Develops New Products?* "Seldom," said Kuhn, "is the developer of a new product the actual source of the original thought or idea." However, he may be, and probably is, solely responsible for its development. While reasons for new products are often clear, said Kuhn, the source of the idea for the new product is usually more obscure.

Kuhn categorized potential sources of ideas as:

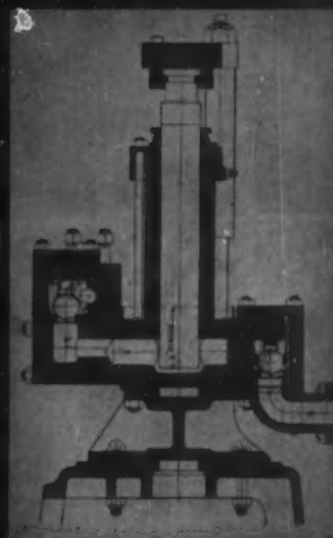
• Internal company communications. Here are included such factors as sales

continued on page 186

**Panel: L. B. Hitchcock, L. B. Hitchcock Associates (chairman); L. A. Hatch, Minnesota Mining & Manufacturing; W. E. Kuhn, Texaco; F. A. Soderberg, F. C. Huyck & Sons; W. J. Riley, Food Machinery and Chemical.*

AT DAVISON CHEMICAL LTD.

Aldrich pumps tame highly abrasive, corrosive slurry in high pressure spray drying operation



Special nylon ball valve construction and stainless steel fluid-end eliminates maintenance problems in handling silica gel at 1800 psi.

When Davison Chemical Ltd. built its new plant in Valleyfield, Quebec, for the production of petroleum catalysts, a major problem was to find a pump that (1) had the abrasion and corrosion resistance to stand up in a continuous high pressure process without down-time or excessive maintenance and (2) could maintain the steady pumping pressures necessary to control particle size, density and porosity of the spray dried product.

What was done: Davison Chemical engineers called on Aldrich for help and the result was the special valve design shown. After two years of continuous operation, the Aldrich pumps continue to deliver constant pressure without major overhaul. The General Manager of the plant reports: "We are quite pleased with the performance of these pumps."

How Aldrich can help you: Solving special pumping problems for the chemical industry is the most important work we do. We would welcome the opportunity to discuss your specific problems . . . no matter what the liquid or slurry, or how high the pressures. Standard Aldrich Pumps range from 25 to 2500 hp. Pressures to 30,000 psi. See our insert in Chemical Engineering Catalog for condensed data. Aldrich Pump Company, 20 Gordon Street, Allentown, Pennsylvania.

the toughest pumping problems go to ALDRICH

For more information, turn to Data Service card, circle No. 127

Development

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department needs, market research studies, competitive activities, performance reports, industrial surveys, "complaints."

• Industry developments. Important things to consider are customer specifications and needs, and techniques or technology in other fields.

• Government developments. Attention must be given to Government development contracts, Government research, and especially to Government-industry conferences.

• Trade and industry publications. Here may be noted new materials on the market, construction of new facilities, and expansion announcements (which may mean more competition).

• Technical contacts. The importance of technical society meetings and committee activities cannot be overemphasized. Kuhn, however, hastened to point out that technical society research activities are hardly a substitute for a company's own research effort.

• Scientific literature. Abstracts of the literature, reports on new analytical tools and procedures, on new materials and new uses for chemicals, and on new chemical engineering approaches, can all be of inestimable value in the search for new product ideas.

• Research and development activities. Technical conferences, patent considerations, fundamental research activities, can not be neglected.

"Today", summed up Kuhn, "the technical man is responsible for product development."

When is development completed?

When is the *Development of a New Product Completed?* "Literally never," said F. A. Soderberg (F. C. Huyck & Sons), who went on to define the maximum and minimum requirements for the completion of a development program. "The absolute minimum to complete any development program," he said, "is the elimination of all the major dangers that may be encountered in the manufacture, marketing, and use of a new product."

The maximum, on the other hand, is when the product has been fully perfected, all minor defects eliminated, and where there is no room for further improvements. This, however, is a Utopia seldom reached in the commercialization of any product. It should be remembered, brought out Soderberg, that if management waits for this maximum effort to be con-

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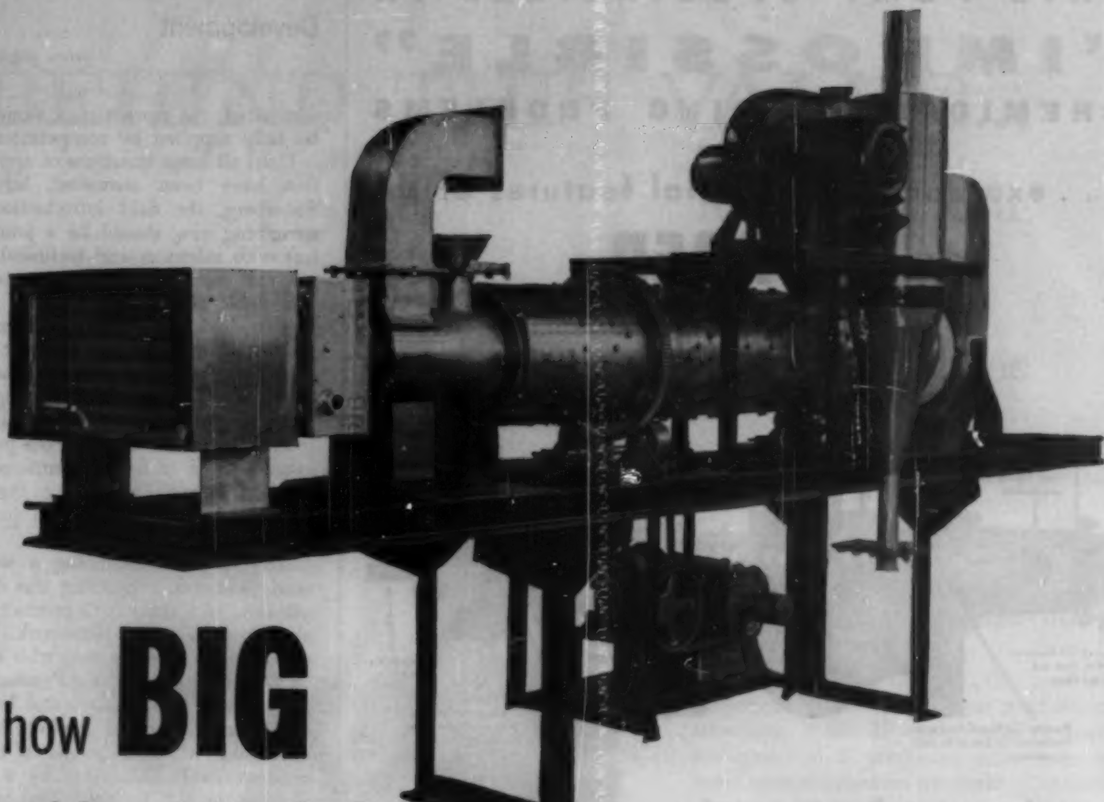

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For more information, turn to Data Service card, circle No. 116

Development

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summated, the market may vanish or be fully supplied by competition.

Until all basic questions of application have been answered, advised Soderberg, the field introduction of something new should be a joint effort with salesman and technical serviceman sharing equal responsibility. The value of this approach, he said, is two fold. The technical service group's knowledge of product use gained during the development period may easily prevent failure during the first days or weeks of use. Many a product has been saved by the proper interpretation of field information relayed by someone who was in the customer's plant to see the full process in operation.

Acquisition is becoming a widely used device in expediting the diversification of a company's product line, according to L. B. Hitchcock, moderator of the symposium, who spoke on *Development of New Products by Acquisition*. Impatient capital has today created a sellers market, Hitchcock said, which is estimated to exceed available businesses by a ratio of from three to ten-fold. This buying pressure has had at least three effects: prices of acquisitions are rising, buyers are reaching out to unrelated businesses, and buyers, particularly those adhering to long-range development plans, are contenting themselves with acquisition of incompleted developments or parts thereof, such as patent rights, market surveys, process or use "know how", and specialized engineering equipment. All of this, concluded Hitchcock, is stimulating inventive and development efforts to license or to be acquired in small, fast-moving companies which thereby find a quicker and more lucrative return than has rewarded traditional efforts to sell undemonstrated inventions or ideas.

The symposium wound up with a talk by W. J. Riley of Food Machinery and Chemical on *The Economics of Evaluation*. "Funds for new developments come from a source of earnings derived from established products and operations. Protection and improvement of the source of earnings, therefore, becomes the first objective of any organization," stated Riley, adding that this objective can be accomplished in many ways, frequently with major assistance from the outside. True innovations, such as the development of new uses or processes, can play important roles. #

Applications of large radiation sources in industry—especially to chemical processes

The Warsaw atomic energy conference — A report

ERNEST J. HENLEY
Stevens Institute of Technology
Hoboken, N. J.

The International Atomic Energy Agency was established by a United Nations Charter in 1957 to "accelerate and enlarge the contribution of Atomic Energy to peace, health, and prosperity throughout the world." The Warsaw Conference on Applications of Large Radiation Sources held September 8-12 was the Agency's first major scientific conference. It attracted approximately 150 delegates from twenty-one countries, and offered the presentation of sixty papers and two general discussions. There were five sessions devoted to radiation sources, two to radiation and chemical reactions, and single sessions on general application, plant genetics, virus inactivation and sterilization, insect control, food preservation, initiation of polymerization and grafting, and plastics and elastomers.

On the topic of Radiation Sources, three major categories of sources were discussed.

Table 1. Cobalt Irradiators

Type of Unit	Curie Strength	Purpose	Countries
Production	2,500,000	Food Irradiator	U.S.
Production	8,500	Potato Irradiator	Canada
Production	100,000	Potato Irradiator	U.S.S.R.
Production	100,000	Sterilization	Australia
Pilot Plant	100,000	Industrial Use	France
Pilot Plant	150,000	Industrial Use	U.K.
Pilot Plant	500,000	Source Development & Industrial Use	U.S.
Pilot Plant	11,500	Polyethylene Polymerization	U.S.S.R.
Research	2,000	Valcanizing Tires	Hungary
Research	10,000	High Polymer Work	Japan
Research	1,800	General Use	Denmark
Research	500	General Use	Hungary
Research	600	General Use	France
Research	450	General Use	France
Research	32	Plant Genetics	Japan
Research	1,800	Botanical Research	U.S.

1. Isotope Sources—Cobalt-60 preempted the major share of attention. No less than sixteen of the papers dealt solely or in part with Co-60 Gamma Irradiators. Table 1 catalogues most of the facilities discussed.

Of all the production facilities listed, only the installations of the U. S. A. and Australia are certain to be built. (Australia's will be used by the Westminster Carpet Co. for sterilizing rugs.) The construction of the Canadian Potato Irradiator is problematical, and private discussions with various people leads one to conclude that the USSR Potato Irradiator (if it exists) is more of a propaganda weapon than a production tool.

The United Kingdom Plant at Wantagh is well along and should be in use shortly (CW/Ipl/87)*. Unlike the American Unit, which will be built at Brookhaven, the British facility will be used primarily for small-scale production, such as sterilization of catheters. The French Unit is also primarily a small production facility and is the only one of the pilot plant facilities which is privately owned in part.

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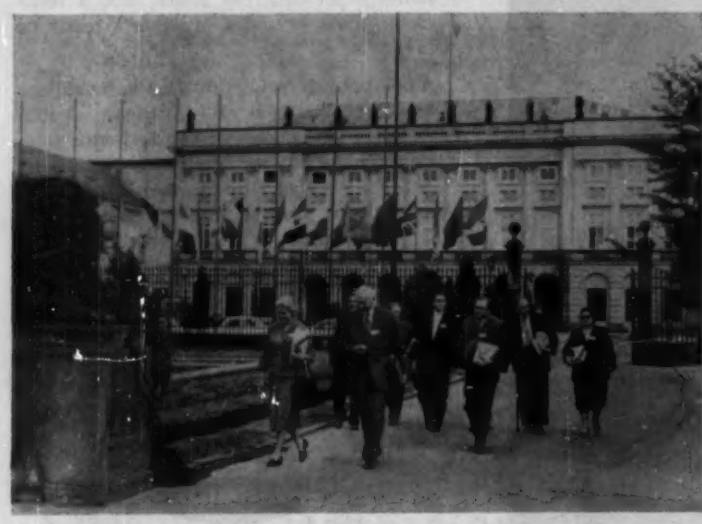
* CW references are to the numbers of the papers which should be available soon in the Proceedings.



Russian delegates leave Warsaw meeting after all day sessions.

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For more information, turn to Data Service card, circle No. 17

Warsaw report

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Research facilities galore were described in a number of papers. Many of these papers seemed superfluous. Small-source technology is quite an advanced art. One need only consider the fact that 105 research irradiators of more than 100 curies each are now in use in the United States alone.

Gross and separated fission product irradiators drew only passing mention. The 100,000 curie HIFAR Fission Product Installation in Australia (CW/Ipl/12), the Dido and Pluto installations in Britain (CW/Ip/85), and the Riso facility in Denmark (CW/Ipl/75) were described in some detail. In addition to these, there were papers on general irradiator design by the U.S. (CW/I/70), and Russia (CW/IIB/-82). Comparisons between Cobalt-60 and fission product sources were drawn by the French (CW/IIIp/41), and Hungarians, (CW/IVB/44d).

Of particular interest was the U.S. Beta Fission Product Irradiator concept (CW/I/69). It was pointed out that for surface modification by graft copolymerization, and for surface pasteurization of foods, weakly penetrating beta emitters enjoy unique advantages in both cost and technology. Beta absorption calculations indicate that extended sources can be designed with power utilization efficiencies as high as 20%. Plans to build a Beta Fission Product Irradiator and 12 kilocurie cesium-137 sources in the United States were announced by Dr. Paul Aebersold, Director of the Office of Isotope Development and head of the U. S. Delegation (CW/5/57).

2. *Nuclear Reactors* — There are several ways in which nuclear reactors can serve as radiation sources.

a) It is possible to circulate a material which undergoes an n,γ reaction through the reactor and then to pass the material into a gamma pit. This concept originated in the United States, and is believed to be uneconomical. A Russian paper (CW/-I/80), described a 200 KW reactor containing 3 liters of Indium-Gallium alloy which would deliver 500 watts of gamma power. The unit has not been built, but design and corrosion studies were said to be in progress.

b) By using a microporous or highly dispersed fuel element, it is possible to absorb the kinetic energy of the fission fragments in a reactant stream, thus recovering anywhere up to 30% of the fission fragment energy directly. (Fission fragment recoil

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Warsaw report

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energy constitutes 80% of the total energy released in fission.) Three interesting papers on this topic were offered. CW/Ip2/24, a British contribution, described experiments in which organic aliphatic liquids, steam-hydrogen, carbon monoxide-hydrogen and nitrogen-oxygen mixtures were irradiated using platinum cylinders coated on the inside with a film of about one micron thickness of U_3O_8. Only the CO-H_2 reaction was reported on in any detail. For this reaction the main product was CO_2, the G (molecules formed/100 EV absorbed) for CH_4 and CHO being less than .3 at best. Another interesting result was the depth dose curves, and their effects on reaction yield. Due to the lower energy of the fission fragments toward the end of their range, an enhanced reaction per unit of energy deposited was observed. The practical implication of these findings is that one need not be so concerned with producing infinitely thin fuel elements.

Belgian scientists (CW/Ip2/13), studied both the radiolysis of methane and nitrogen fixation using carbon-uranium microporous fuel elements. They discovered a number of anomalous effects as the catalyst support and pore size of the catalyst was varied. These are, as yet, unexplained.

The United States' contribution (CW/Ip2/23) consisted of a report of the present status of nitrogen fixation by reactor radiation using a dispersion of uranium-235 in glass fibers about five microns in diameter. Work is now in progress inside a loop at the Brookhaven pile at 10 Atm and 100-150°C. Results obtained to date indicate that decontamination may not be a problem, and that G values close to the theoretical value of nine can be obtained. On the debit side is the fact that pure oxygen and nitrogen (sans argon and water vapor) must be used. This seriously affects the economics and it is almost universally agreed that the process is not economically attractive unless a dual purpose (power and chemo-nuclear) reactor is utilized.

c) An unscheduled, un-numbered paper by L. S. Mims of Atomics International ended the Reactor Sessions. Mims disclosed the results of a Design Study of a Chemonuclear Dual Fluid Reactor. Diphenyl or polyphenyl is to be used as the coolant while the chemical reactants circulate in an adjacent loop. It was stated that one megawatt of irradia-

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tion power could be delivered with a 35% efficiency at a cost of ten cents per KWH. By-product steam of electricity could presumably cut this cost figure in half.

3. *Electron Accelerators*—The only paper submitted was devoted to the study of the economics of the production use of electron beam radiation for irradiating polyethylene (CW/IIIp/-54). It was shown that, using the General Electric Resonance Generator, a cost of half a cent per megarad/pound had been achieved. It was stated that the radiation power of an electron machine operating or being installed for production processing exceeds 100 kilowatts. In terms of crosslinked polyethylene, this is equivalent to 25x10⁶ pounds per year.

Radiation effects on plastics

The session on *Radiation Effects on Plastics and Elastomers* had no American papers dealing with ionizing radiation. There were two Belgian offerings, (CW/IIA/6) and CW/IIA/5d). The former dealt with crosslinking of polyethylacrylate and reported among other things that degradation is of the indirect type involving oxygen and solvent, while crosslinking begins only at polymer concentration above 5% and at 25% it is predominant. The latter paper described the crosslinking of polyvinyl alcohol where similar effects were observed. The authors attribute the decrease in viscosity at low concentration to microgel formation.

An interesting British paper (CW/-IIA/8) related attempts to lower the cross-linking doses for polyvinylchloride by adding multi-functional monomors, namely diallyl and triallyl esters. The mixtures become cross-linked with doses in the range of 8-25 megarads, and led to products which may be regarded as PVC attenuated allyl network polymers.

Two Japanese contributions were included. One dealt with effects on polyvinyl-alcohol (CW/IIA/37), the other was an electron resonance spin study of irradiated polymers (CW/-IIA/31). The latter paper served to accentuate the fact that, to date, ESR Spectra have not contributed much to the general understanding of radiation effects.

There were eleven papers on *Radiation Polymerization and Grafting*. Of interest were the Russian studies of the polymerization of ethylene

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(CW/IIB/82), and (CW/I/81). They reported that although the rate of solution polymerization is fifty times higher than the gas phase reaction, the product had too low a molecular weight to be of commercial interest even when produced at pressures up to fifty atmospheres. A great deal of rate data for the gas phase reaction was offered. The rate increases with pressure between 100—300 Atm, there is a dose rate dependence to the one-third power and a corresponding reciprocal molecular weight relationship, however the molecular weight increases with pressure. G values up to 5,000 were obtained and the product has a density of .75, a high crystallinity, a viscosity of 1—1.5, a breaking point of 150-200 kg/cm², a lengthening of 300-350%, and in general was said to resemble high pressure PE. The Russians are building a pilot plant and are optimistic regarding the commercial possibilities of the process.

By strength of numbers, the Japanese dominated the polymer sessions. There was a paper on vinyl acetate polymerization (CW/IIB/33d) both in solution and emulsion. New work on primary processes was presented (CW/IIB/33d). Liquid scintillation in p-terphenyl was used to demonstrate energy transfer to dissolved monomers and polymers. In monomers the ease of energy transfer was found to be in the order: conjugated monomer > unconjugated monomer > saturated compounds. For the polymers, the sequence was crepe rubber > polystyrene > polyvinylacetate > acrylic polymers. The second part of the paper dealt with the cationic polymerization of styrene and styrene—methyl methacrylate mixture in methylene dichloride at −80°C.

The other two Japanese papers were on the subject of grafting (CW/IIB/39, and CW/IIB/36). The former dealt with the graft copolymerization of styrene, methyl methacrylate, acrylonitrile and vinylacetate to polyvinylalcohol. Of particular importance were the findings with regard to the necessity for the presence of water, either in the monomer or polymer. It is presumed that the water serves as a swelling agent in the absence of which no monomer can penetrate the films. CW/IIB/36 described graft copolymerization on the surface and inner-layer of fibres. Surface grafting of acrylamide onto nylon was achieved by pre-irradiation of the fiber in nitrogen followed by solution grafting. Inner-layer grafts were obtained when the pre-irradiations were done in oxygen. This phenomenon can be explained on the basis that in the presence of oxygen the fiber degrades thus facilitating diffusion of monomer into the polymer.

Graft copolymer papers were also offered by the Hungarians (CW/IIB/3) and British, (CW/IIB/17), (CW/IIB/86). The Hungarian effort was directed towards maximizing the ratio of graft to homopolymer by using low dose rates and applying the radiation intermittently, preferably in the presence of a redox catalyst. CW/IIB/17 represents a careful kinetic study of the graft polymerization of acrylonitrile in polydimethylsiloxane solutions. The reaction was found to be kinetically similar to the aqueous solution polymerization of acrylonitrile, and a similar reaction mechanism was evoked. The other (CW/IIB/86) described efforts to improve the electrical properties of nylon by grafting small amounts of methacrylic acid.

Part 2 in December CEP.

For more information, circle No. 141

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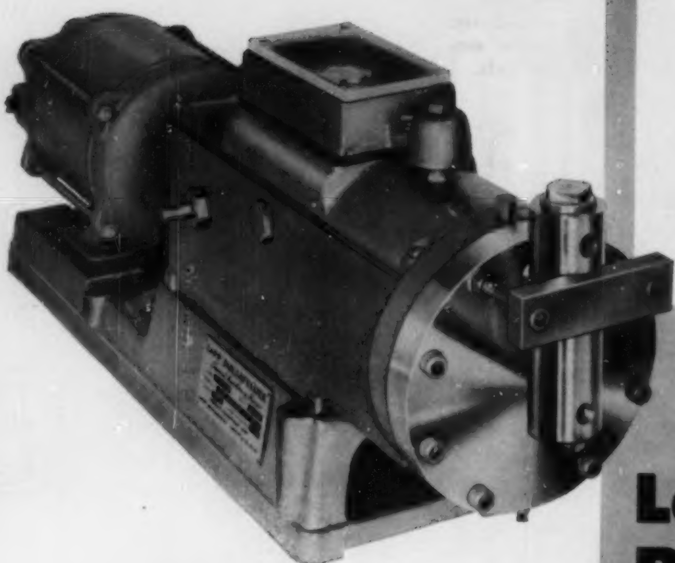

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For more information, turn to Data Service card, circle No. 18

meeting preview

San Francisco highlights

December 6-9th

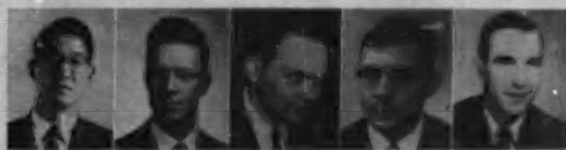
SAN FRANCISCO HAS REALLY rolled out the red carpet for visitors to the 52nd Annual Meeting, with the Mayor of the city on hand to greet attending members at the formal opening of the meeting Monday morning. This session will also hear the Annual Institute Lecture by Thomas H. Chilton. He will talk on *Nitric Acid by Ammonia Oxidation*. At the Awards Banquet, traditionally a featured event, Chancellor Glen T. Seaborg, University of California, will be keynote speaker, giving a status report on Nuclear Research.

Joint Symposium

Special attraction on the technical program is a symposium series on petroleum recovery methods. Jointly sponsored by the Society of Petroleum Engineers (AIME) and A. I. Ch. E., the three sessions are part of a long range program of collaboration between the two organizations. One will deal with *Thermal Methods of Petroleum Recovery*, including in situ combination. Tuesday's discussions *continued on page 204*

Know your authors

Monday Afternoon



Kunii Smith Berry Bailey Larkin

Somerton Torobin Gauvin Walsh Manning Wilhelm

Bartok Heath Weiss Van Deemter Comley Reed Updegraff De Long Thayer Scotten

Sze Barr Friedman Gross Olson Levine Swift Lohrenz Kurata Grieves

Thodos Forman Wilke Steinberger Treybal Friedlander Toor

Tuesday Morning

Benham Dowden

Kunzman Hutchinson Braun Iscol Edwards Altpeter Huckaba Lapidus Nissan Hansen

Cowan Zieminski Vermillion Ratkowsky Carlson Schowalter Johnstone Norwood Metzner

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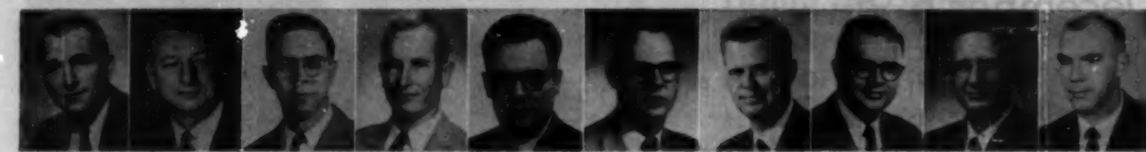
San Francisco highlights

continued

Tuesday Afternoon

Perrine · Raimondi · Gardner · Petrick · Brigham · Reed

Dew · Cowan · Johnson · Marr · Pigford · Fricke · Morris · Otto · Williams · Min

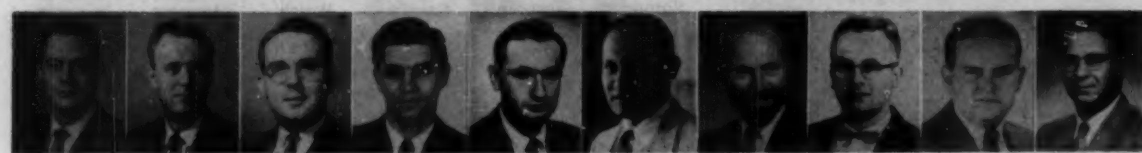


Basilevsky · Schumacher · Lewis · Menard · Hulburt · Pauls · Comings · White · Schechter · Wissler

Gealer · Churchill

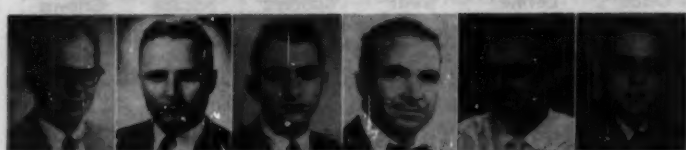
Wednesday Morning

Gilbert · Knight · Beuther · Flinn · Herthel · Reynolds · Roe



Reif · Kress · Smith · Gossett · Ornea · Stillson · Wilde · Kellett · Perley · Singer

Richardson · Uhl · Tsubouchi · Sato · Knudsen · Rosen · Hanratty · Gordon · Larkins · Jeffrey



Von Halle · Jury · Winnick · Powers · Kurtz · Burchard

Wednesday Afternoon

Ditman · Flanders · Girard

Laughlin · Dickinson · Longsworth · Hood · Atteridg · Collopy · Blum · Bostian · Smutz · Weaver

Kappelman · Sobotik · Himmelblau · Burkhart · Stevens · Lauher · Happel · Hughmark · Pressburg · Tek

San Francisco

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will cover *Miscible Fluid Displacement.* Chairman is Fred H. Poettman, Ohio Oil, and co-chairman, J. J. McKetta.

Dynamic objectives

Dynamic objectives of Chemical Engineering will be the topic of a general discussion meeting on Tuesday. Sponsorship is by a new Institute committee working in this field under the chairmanship of R. R. White, University of Michigan. To be held in the California and English rooms on the second floor of the Sheraton-Palace, the meeting is open to all, and all engineers are urged to attend and help with their views.

A panel discussion on creativity, scheduled for Sunday afternoon, promises to be of interest. Moderator is T. H. Chilton and topics to be taken up are: *The Creative Process, Characteristics of the Creative Individual, Organizing to Stimulate Creativity, and Organizing to Suppress Creativity.*

Other highlights of the meeting are the Presidents' luncheon, with D. L. Katz speaking on *Goals for A.I.Ch.E.*, and the Professional Progress Award Lecture by W. R. Marshall.

Plant tours

Visitors can choose from any one of a dozen plant tours, including Dow Chemical, GE's Vallecitos Atomic Laboratory, UCLA's Lawrence Radiation Lab, Standard Oil's Richmond Refinery.

The ladies' program is calculated to keep the ladies busy every minute. It includes a fashion-show luncheon, one at famous Fisherman's Wharf, a scenic tour of the city, and, of course, the evening in Chinatown planned for all those attending the meeting.

Canada's expansion in nuclear energy research and development continues with plans for a center at Manitoba, to be built at a site still under consideration. Tentative plans call for an organic-cooled, natural uranium-fuelled, heavy water moderated power experiment in about two years' time. The government owned company also operates Canada's other major research center at Chalk River, near Ottawa.

A company just formed to manufacture weed killers will headquarter in Paris. The wholly-owned subsidiary of Du Pont, Du Pont de Nemours (France), S.A., will make "Telvar" monuron and "Karmex" diuron weed killers for industrial and agricultural use.

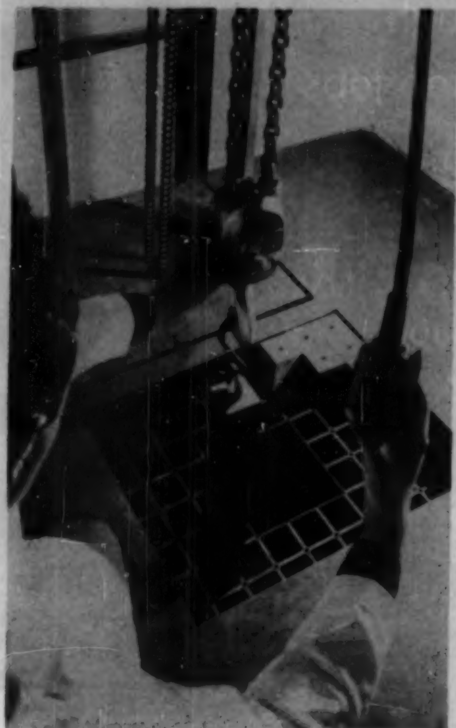
industrial news

A high purity hydrogen plant now under construction for Wesson Oil will produce 325,000 cubic feet per day, is scheduled to go onstream late this year at Memphis, Tennessee. The unit produces hydrogen by the steam reforming of natural gas. It will replace a smaller electrolytic hydrogen plant to provide increased capacity for the manufacture of shortenings for commercial cookery.

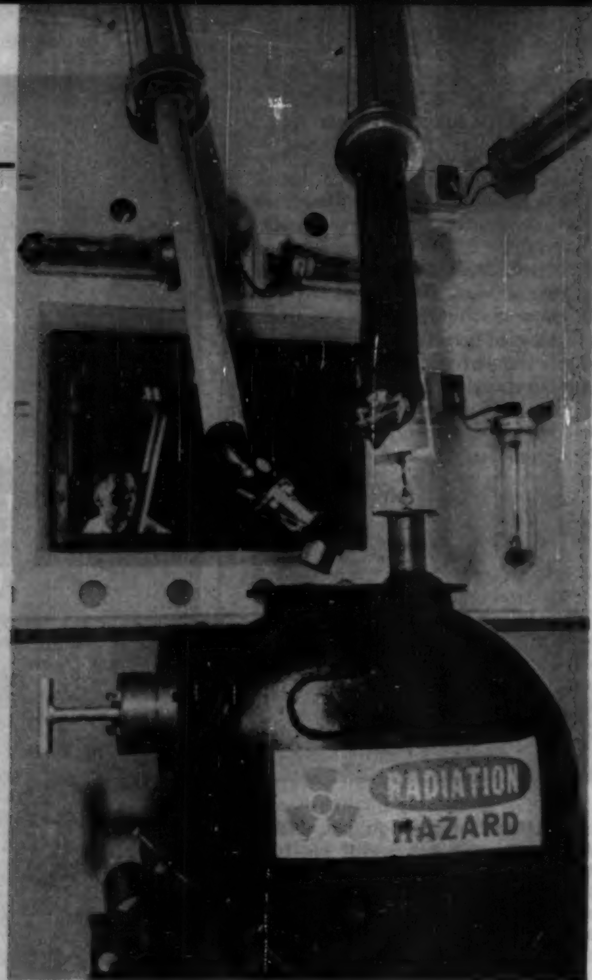
A distillate desulfurization unit of 8000 BPD capacity recently went onstream at British American Oil's Clarkson, Canada, refinery. The unit, designed to remove 90 percent of the sulfur content in fluid cat cracking light cycle oil, stove and diesel base, will run in blocked operation with intermediate storage. Reformer gas supplies oxygen, and a pellitized cobalt moly catalyst will be used. Capacity can be doubled on the Kellogg-designed unit with minimum changes.

A fourth link will be added to Linde's chain of liquid oxygen-nitrogen plants when a 135 ton a day unit goes onstream next year at Neosho, Missouri. Built to supply missile installations with cryogenic fluids, the new plant will be located near the missile engine production facilities at Fort Crowder reservation. The plant will primarily serve the government, but it will be integrated into the Carbide division's distribution network serving the southwest.

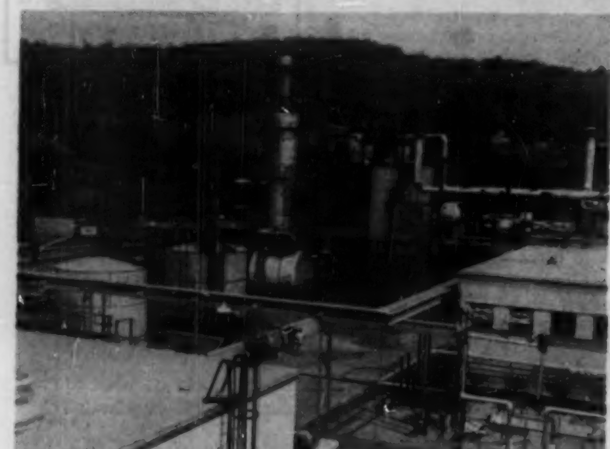
A 50 million pound increase in production capacity of polyethylene resins (Petrothene) at US Industrial Chemicals, is expected to make the company the second largest polyethylene producers in the world. Company capacity will be 300 million pounds a year when expansion is completed. Annual output at USI's Houston, Texas, plant is being upped from 75 to 150 million pounds. At the Tuscola, Illinois, plant, production is 100 million pounds a year.



Gamma "garden," the main storage vault for radioisotopes at the Picker Research Center (see right.)

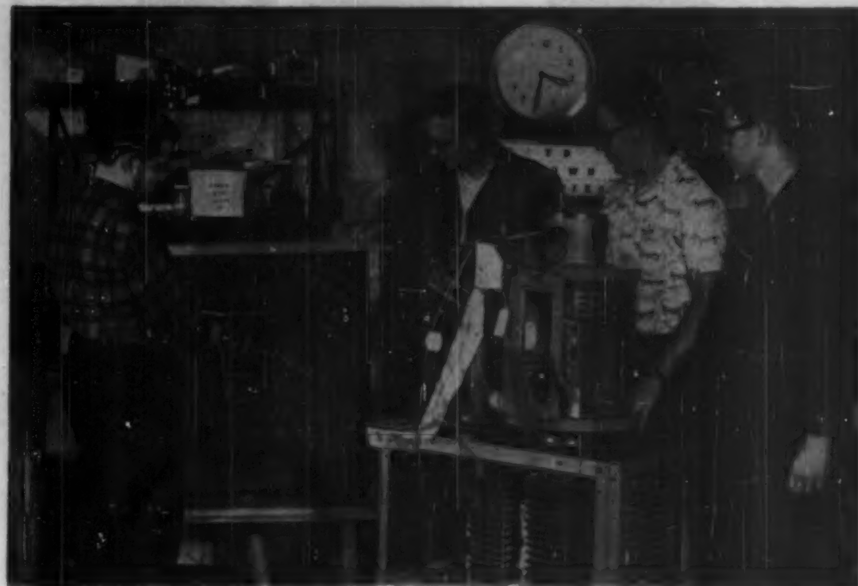


The new Picker Research Center at Cleveland is the nation's largest non-Government installation for storing, processing, and studying radioisotopes.



Cyanamid gets into the maleic anhydride field with this new Bridgeville, Pa., plant in the final stages of construction.

Pipeline being built for Moa Bay nickel project of Freeport Sulphur. When finished the line will carry a "river" of nickel-cobalt slurry down to processing plant.



High school students build full scale computer under Boyd's direction.

A. I. Ch. E. member Dave Boyd (left) of Universal Oil Products works with Hinsdale (Ill.) High School students to build a computer in his basement. With Boyd are (l. to r.) Richard Barnes, physics teacher, and students Bob Getsla and Garry Boyd.

Contingent of Hinsdale High students work diligently on the highly complicated computer-building project under Boyd's direction.

An unusually large "packaged" type low-temperature gas separation plant was recently designed and built by Air Liquide for American Chemical Corp. Here, a 60-ton section is readied for shipment.

local sections

Chemical industry in Western Europe, New York 25th anniversary, at local sections

Production of chemicals in Western Europe is currently about 57 percent of that in the United States, but chemical industry there is growing at a more rapid rate. And so is chemical engineering technology making rapid strides. These facts came from Ernest S. Sellers of Swansea, Wales. Sellers, head of the Chemical Engineering Department at the University College of Swansea, addressed the Northern West Virginia Section (*W. H. Holstein*) meeting in September. Only in the production of chemical fertilizers does Western Europe surpass the United States, he said. Productivity is lower, however, so that overall labor costs per unit of production are nearly equal in both areas.

A 60 percent increase since 1953 in European chemical industry has brought concern over the problem of an adequate power supply. Power consumption per worker in the United States is about three times that for the worker in Europe. Mechanization of coal mining facilities in some places, and bringing in oil refining to Europe from the near east was one solution to the problem. Currently, it is estimated that coal and oil will handle power requirements for the next 15-25 years. In addition, nuclear power plants are depended upon to start scheduled operations within the next few years.

Growth of the chemical industry in Western Europe has promoted the growth of chemical engineering tech-

nology, which, in turn, has contributed to a further growth of the industry. Development of chemical engineering science in the British Isles as a whole is most encouraging, considering the fact that it was only 1956 when by grant of a royal charter in Britain, chemical engineering was recognized as a primary technology on a par with civil, engineering and electrical engineering. Although the subject was taught in some universities before the war, it was 1949 before Cambridge University established a separate department. Since that time, most of the other Universities and Technical colleges have started to teach similar courses.

Vapor equilibrium

The design and operation of distillation columns in natural gasoline, refining and petrochemical plants require an accurate knowledge of the vapor equilibrium properties of the stocks to be fractionated. But since required equilibrium data are seldom available when needed and are often time consuming or costly to obtain, generalized correlations provide a means of bridging the gap. This is particularly so where sufficient experimental data is lacking, R. A. Greenkorn told the Bartlesville Section (*S. J. Marwill*) in September. Greenkorn, Jersey Production Research Company of Tulsa, Oklahoma, reviewed basic terminology, and established a criteria for equilibrium based on the first law of themodynamics.

Fugacity, activity, vapor-liquid equilibrium constants were used in developing a generalized formulation. Reduced temperature, reduced pressure and the critical compressibility factor were all used to obtain a generalized K chart. Use of this chart was illustrated in the calculation of an x-y diagram for a binary propane isobutylene mixture and calculation of the bubble point temperature and vapor composition of a mixture of propane, normal butane and normal pentane. Calculated values were shown to be in close agreement with experimental data.

The correlation did not work well for methane systems, but this is not surprising, since the various properties of methane were known not to correlate well. The critical temperature of methane is well below that of the paraffin hydrocarbons. The correlation, however, does give results close to idealized K'S.

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local sections

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New York-25 years

To celebrate its 25th anniversary, the New York Section (*Cal Cronan*) devoted the September meeting to recognition of past chairman. Fifteen former heads of the group were on hand to receive lapel pins and past-chairman certificates.

Presentations were made to: (l. to r. in the picture above) P. E. Landolt (charter chairman), Stephen L. Tyler, John P. Hubbell, C. L. Knowles, Donald F. Othmer, Lincoln T. Work, Emerson J. Lyons, Robert L. Taylor, W. D. Kohlins, Francis B. White, Dick Shaffer, C. H. Chilton, J. F. Lawrence, Tom Jackson, Max Strawn. The awards were presented by L. C. Kemp, Jr., a director of the Institute, and member of the New York Section.

News from New Jersey

The New Jersey Sections are in full swing, with the fall kick-off meeting of the New Jersey Section (*S. A. Sovitt*) featuring J. T. Grey, who talked on rocket propulsion systems. Advances made by the United States in the field within the past few years, what's ahead for this new science, as well as a rundown on its present state, were all covered by Grey. He is head of the research planning staff at Thiokol Chemical.

A talk on missile weaponry drew a capacity crowd to the North Jersey Section in September. Various aspects of the development of atomic weapons was discussed by Robert M. Schwartz, associate director for atomic weapons at Feltman Research and Development Laboratories.

New Section

East Texas joined the ranks of A.I.Ch.E. as an official local section when the charter was formally presented at the October meeting. Speaker at the program banquet, was J. D. Lindsey. He traced the growth of the chemical industry in Texas.

Undergraduate curricula

Should undergraduate curricula in engineering be eliminated in favor of professional schools? Divided to emphasize both science and technology? Extended to five years? What should be the nature and role of graduate engineering education? All these questions were taken up at the **Rochester Section** *(Robert L. Cramer)* in October. The group met jointly with ASME, AIEE and IRE. Speaker was John W. Graham, Jr, dean, College of Engineering, University of Rochester. Topic: Education for Creative leadership in Engineering.

Also meeting

At the **Alton-Wood River Section** *(J. G. Huddle)* in September, Robert S. Kuehne, Shell Oil, spoke on linear programming. Talk centered around new techniques to determine the optimum way to operate the process industries . . . The Illinois Chemical Industry was surveyed at the Chicago **Section** *(R. L. Opila)* in October. William F. Mitchell, general manager, Chemical Division General Mills, was the speaker . . . A behind the scenes picture of the role of insurance in the chemical industry was given to the **Western Massachusetts Section** *(A. N. Major)*. Occasion was the Hartford Regional meeting in October. The speaker, Reuel C. Stratton, assistant director chemical and nuclear research, Travelers Insurance, also touched on risks involved . . . New chemical engineering building on the Ohio State campus was visited by the **Central Ohio Section** *(Joseph H. Oxley)* in September. Joseph H. Koffolt, head of the department, conducted them on the tour. . . . The Ichthyologists **Boston Section** *(Ralph Wentworth)* saw the A. D. Little plant in North Cambridge, Mass. as part of their October meeting. They also heard a member of the company's operations research section, Sherman Kingsbury, discuss the non-rational side of decision making . . . Leon Jacolev gave the **North Jersey Section** *(S. A. Savitt)* meeting in October a chemical engineers' impression of Russia. Jacolev, Associated Technical Service, represented the Institute at the Eighth Mendeleev Congress of Pure and General Applied Chemistry. . . . The subject of cryogenics took up the October meeting of the **Western New York Section** *(Reed E. Garver)*.

institutional news

Special sessions on automatic control theory

A step on what may be the major path to the solution of the problem of providing trained instructors in automatic control was taken this summer at Cleveland's Case Institute.

A special course on automatic control theory, held this summer, may be one answer to a long standing problem in chemical engineering education—providing trained instructors in the field. The three-week conference on modern automatic control and process dynamics at Case Institute was attended by twenty-seven instructors of chemical engineering. Sponsorship was by A.I.Ch.E. and FIER, while finances for the course were provided by a grant from the National Science Foundation. It is hoped that this was a first step in making such courses available in each of the 118 Chemical Engineering Departments thruout the country.

The classes, titled *Summer Study Program in Process Control Theory for College Teachers of Chemical Engineering*, discussed the latest techniques of process control. One of the objectives of the program was to develop methods and techniques of dynamic analysis as applied to process control. The course itself consisted of ten lectures. Subjects included solution of differential equations by classical and operational methods, generalized impedance concepts, feedback concepts, graphical representations, liquid level control, etc. Also included were four laboratory sessions, two system analysis periods, and four recitation periods weekly.

The course was conducted by D. P. Eckman and Irving Lefkowitz and their associates in the Mechanical Engineering Department at the Cleveland, Ohio, technological institute.

Construction on a chemical solvent and intermediate plant goes ahead on the facilities at Brownsville, Texas, purchased by Union Carbide from Amoco. The plant will be operated by Union Carbide Chemicals and Union Carbide Olefins, both divisions of the parent firm. Completion schedule is March 1961; market will be textile, pharmaceutical, and surface coating industries.

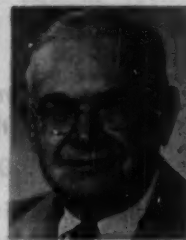
For more information, turn to Data Service card, circle No. 130

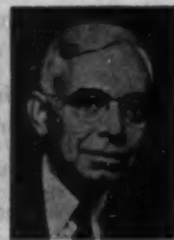
For more information, turn to Data Service card, circle No. 68

people {in management and technology

Curtis and McAdams receive Founders' Awards of A.I.Ch.E.

One of the highest honors of A.I.Ch.E., the Founders Award, goes to two men this year: **William H. McAdams** and **Francis J. Curtis.** Presentation will be made at the Awards Banquet at the San Francisco Annual Meeting, December 6-9.





Winners Curtis, McAdams

William H. McAdams was professor at Massachusetts Institute of Technology until he became professor emeritus and lecturer upon his retirement this summer. Credited with developing many of MIT's graduate courses in chemical engineering, McAdams received the William H. Walker Award of the Institute and the Worcester Reed Warner Medal of ASME for his work on heat transmission. He holds an honorary doctorate from the University of Kentucky and was given the President's Certificate of Merit for World War II service as project supervisor for the National Advisory Committee for Aeronautics and National Defense Research Committee. The educator also received, in 1958, the gold medal of the French Institute of Fuels and Energy, for "the internationally known works of an eminent engineer from the United States." Author of *Heat Transmission*, and co-author of *Prin-*

ciples of Chemical Engineering, he has been a consulting chemical engineer since 1919, and a lecturer at Harvard University since 1925.

Francis J. Curtis, the other recipient of the Founders Award, has held the post of vice president of Monsanto since 1943, and member of the Board of Directors since 1949. For the past several years, until his recent retirement, he was coordinator of personnel relations and secretary of the executive and finance committee. Curtis was with Monsanto since 1915 when he joined the research department of Merrimac Chemical, a company taken over by Monsanto in 1929.

Curtis also served as the company's director of Industrial Preparedness in Washington. In 1952, at Aberdeen, Scotland, he was elected president of the Society of the Chemical Industry, an international organization of industrial chemists. He is a past president of the A.I.Ch.E., and held office in several other leading professional societies.

Student contest winners

First prize in the A. I. Ch. E. student contest went to a student at the University of Illinois, J. R. Griffin of Du Quoin, Illinois. Griffin placed first in the Institute's Student Problem contest. The prize, titled the A. McLaren White Award, is made for the best solution of a problem in Chemical engineering.

Second place, the A. E. Marshall Award, went to L. G. Rossa, of Purdue University. Third prize went to W. J. Lee of Sweetwater, Texas, a student at Georgia Institute of Technology.

Honorable mentions went to J. L. Schlechte, Lamar State College, Beaumont, Texas; T. W. Carroll, Cincinnati, Ohio, Yale University, and J. C. Kennedy, New Orleans, La., Tulane University.

The awards, which consist of \$200 for first place, \$100 for second and \$50 for third place, will be presented at the Awards Banquet.

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Franklin Institute award to Oberfell

George G. Oberfell has been awarded the Walton Clark Medal from the Franklin Institute. The Medal Citation from the 135 year old scientific organization reads: In consideration of his significant contributions to the development of liquid petroleum gas as a source of domestic fuel.

Oberfell was vice president in charge of research and development at Phillips Petroleum until 1950. Under his direction, research at the company laboratories, in addition to the work on liquid petroleum gas, resulted in charcoal adsorption as a testing method of gasoline extraction; improved oil absorption natural gasoline extraction processes; low temperature fractional analysis of low boiling hydrocarbons; isomerization of paraffins; and catalytic cracking processes for improving yields of gas and oil products.

Now retired after 25 years with the company, Oberfell spends part of his time as consultant in petroleum, natural gas and chemicals.

The retired executive is a past director of the Institute. He holds 33 patents, is author of numerous technical articles, and co-author of two

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books, *Natural Gasoline*, and *Natural Gasoline and the Volatile Hydrocarbons*.

He received the award at ceremonies at the Franklin Institute in Philadelphia on October 21.

Price wins Fritz Medal

Top prize of the engineering fraternity, the John Fritz Medal, has been awarded to **Gwilym A. Price.** Chairman of the board of Westinghouse Electric Corp., Price is the first man with a non-engineering background to receive the award in its 58 year history.

The gold medal was given to the industrialist for "his inspirational leadership, industrial pioneering and personal initiative in marshalling the creative forces of research and engineering to the cause of developing atomic power for the national defense and for human welfare". Representatives of four national societies, ASCE, AIME, ASME, and AIEE, voted him the award. (A.I.Ch.E. became, in October, the fifth society to administer the prize.)

After World War II, Price formed an atomic power organization within his company to harness the atom for practical uses. The historic atom plant for the USS Nautilus was developed. Nuclear propulsion plants for the Polaris-firing submarine, USS George Washington, and the Navy's first atomic surface ship, USS Long Beach, were designed by men he brought together. They also produced the nation's first full-scale atomic-electric generating station at Shippingport, Pa., a pioneering step in the development of atomic power.

Other plants now being built by Westinghouse are the 134,000 kilowatt Yankee Atomic Electric, and the 11,500 kilowatt plant for Belgium (the nation's first exported commercial atomic electric plant). It is hoped that atomic energy will, as Price puts it, "overcome and destroy those roots of war—poverty, insecurity and fear."

The Award Board felt that such contributions in a new technical field abundantly merit the honor of the

John Fritz Medal. Other recipients of the annual award have been Alexander Graham Bell, Thomas A. Edison, Orville Wright, and Herbert Hoover.

Theodore J. Williams was lecturer for the Fourth Annual E. P. Schoch Series, held at the University of Texas in October. Williams, who is with Monsanto, St. Louis, talked on Process Control, touching on highlights of basic theory, and evaluating present status of the field as well as future trends. The 2-day series, named for E. P. Schoch, of the Chemical Engineering faculty at the Austin, Texas, University, is made possible by contributions from ex-students, friends, and industries in Texas and surrounding states.

In recent changes within the Chlorinated Products Division, Diamond Alkali, **Z. A. Stanfield** transferred to the Greens Bayou plant, Houston, Texas, as technical superintendent. Named to succeed him in the same post at Belle, West Virginia, is **D. R. Pulver.** Pulver was formerly senior engineer at Cleveland, Ohio.

Robert L. Taylor named to the newly created position of manager of organization and management development at Olin Mathieson. He was previously assistant to the general manager of industrial chemicals.

Edward F. Thode appointed chief of The Institute of Paper Chemistry's Pulping and Papermaking Section. He had been a member of the chemical engineering group at Appleton, Wisconsin.

Stephen E. Taub made acting chief, Engineering Department, Foster D. Snell. Taub, co-author of a number of articles on soluble coffee processes, moves up from the position of project engineer in the same department at Snell. He replaces **Gabriel Appleman,**

(left) who resigned to become plant engineer at Ansbacher-Siegle, pigment manufacturing subsidiary of Sun Chemical. Previous to his association with Foster Snell, Appleman worked with Fertilizers and Chemical, Ltd. As assistant to the director, research and development, he helped plan the company's phosphatic and nitrogen fertilizer complex at Haifa, Israel.

Reuben Gutoff takes over the position

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of specialist in project evaluation of GE's chemical development operation at Bridgeport, Connecticut, Chemical and Metallurgical Division. He was with the company's silicone plant at Waterford, New York.

C. Vernon Foster has joined the Boston consulting engineering firm of H. C. Schutt. Foster's background includes work as group leader in Continental Oil's R & D Department; with Ethyl as process engineer, and in C. F. Braun's Research Department.

John W. Hoopes becomes director of Atlas Powder's Chemical Engineering Department, Chemicals Division. Hoopes, who joined the company in 1955, was manager of the process engineering section, then assistant director of the department. He also taught at Columbia University. He succeeds **Marshall T. Sanders,** who was director of the department since its formation in 1945. Sanders is eligible for retirement, but will remain as technical assistant to the executive vice president.

Henry K. Dice appointed vice president-technical director, Celanese Chemical. Dice has been with Celanese Corp. since 1934, serving at several plants, most recently as manager, chemical research and development. His office will continue at the research laboratories, Clarkwood, Texas.

H. G. Corneil promoted to research associate, Humble Oil & Refining. Corneil's work is in petrochemicals and nuclear energy studies, in the research and development division, Baytown, Texas.

Kenneth H. Speckhals joined Colgate-Palmolive's Household Products Research and Development Department, evaluations section. He comes to Colgate directly from the University of Pittsburgh, where he was associate editor of the student engineering magazine.

Norman H. Blumberg appointed to the new post of manager of organiza-

tion and development at Merck. Blumberg, a member of the firm since 1939, was director of systems and data processing, and acting treasurer of Merck's Canadian subsidiary.

Lawrence B. Trenholme will head the Works Engineering Department of Union Carbide Chemicals, Texas City, Texas. Trenholme, with Carbide since 1943, was most recently a project engineer. For several years prior to 1957, he acted as resins engineering coordinator for the company.

Arnold Kivnick appointed group leader, Process Engineering Department, Pennsalt Chemicals. He is head of a cost estimating group in the Research and Development Lab., Wyndmoor, Pa.

Additions to the staff of Atlantic Refining are **E. M. Phillips, D. Mykytiuk,** and **H. A. Sorgenti.** All three are in the Research and Development Department as assistant development engineers.

New plant manager at Mobay Chemical, New Martinsville, West Va., is **W. P. Dunlap.** Dunlap, who joined the company in 1958 as production superintendent, had been with Monsanto since 1947. Other new assignments are: **R. M. Ewald,** general operating supervisor, and **J. W. McCrackin,** polycarbonate supervisor.

DeWitt O. Myatt has resigned his post as head of the development department at Atlantic Research to start his own research and consulting firm, Science Communication, Inc. He continues as consultant on development to the company.

New member of the Development Department at Atlantic Research is **David B. Roberts.**

Jay E. Trexler has joined Toledo Scale as manager, engineering services. Trexler, who has been in the petroleum refining industry for over fifteen years, was formerly with Pure Oil in Toledo.

In key staff changes at Monsanto, **David M. Williamson** moves to the newly created position of director of

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manufacturing for the West Coast. **Roland H. Dunlop** has been named plant manager, a post which Williamson held in addition to his other duties.

Myron T. Foveaux named manager, special projects research for the Office of Civic Affairs of Monsanto, St. Louis. Also at St. Louis, **James F. Adams** was appointed section leader in charge of research groups on interim manufacturing, engineering and economic evaluations, and on mechanical engineering. In the research pilot plant, **William G. Knapp** was named group leader.

Lauchlin M. Currie has been named chairman of a five-man policy making committee of the annual Nuclear Congresses. Currie, a director of Babcock & Wilcox, and vice president in charge of the Atomic Energy division, was chosen for the post by 28 engineering and industrial organizations. The groups are sponsors of the 1960 Nuclear Congress.

Currie has been connected with the American atomic energy program since 1943, when he was associate director of war research for the Manhattan district atom bomb project. He attended the first Atoms for Peace Conference in Geneva, Switzerland, in 1955, where he was a member both of the U.S. delegation and the U.N. Secretariat. In addition, Currie served as U.S. representative at the conference of the organization for European Economic Cooperation in Nancy, France.

He was with Union Carbide for over 30 years, leaving the post of vice president of Union Carbide Nuclear to join Babcock & Wilcox.

Others members of the Nuclear Congress planning committee are: **George E. Holbrook**, vice president, Du Pont, and past-president of A.I.Ch.E. **Wilbur E. Kelley**, president, Associated Nucleonics; **C. Rogers Mc Cullough**, Monsanto; and **John R. Dunning.**

people in marketing

J. E. Carr appointed manager, Chemical Processing and Sewage Treatment Equipment Division at Denver Equipment. Carr, who has been on the sales staff of the company for three years, is a 1943 graduate of the University of Colorado.

Robert M. Stroman takes over as molding compound salesman in Hooker Chemical's eastern territory. Headquarters are in New York City.

James M. Young III has joined the newly formed market development section in Hooker's Eastern Sales Department.

Fred S. Hirsekorn appointed technical service representative at Frontier Chemical Division, Vulcan Materials. Hirsekorn has been with the Wichita-based company since 1957 as process engineer.

James Boyd Smith named manager, sales development for refinery chemicals, at American Cyanamid's Industrial Chemicals Division.

Robert A. Culberson has joined the Sales Department of Monsanto's Organic Chemicals Division, St. Louis, Mo.

In elections held by the Chemical Industry Association recently, **Richard S. Mooney** became secretary of the organization, and **Herbert W. McNulty** was named to the board of directors.

Jack Hopper joined Process Sales Company as sales and service engineer. Hopper was formerly with Duriron, working out of the Houston, Texas, office. He was also associated for several years with Phillips Petroleum, in process engineering and plant maintenance.

Anthony M. Johnson, Jr. takes over the post of assistant marketing manager, Beckman Instruments. He is in the systems Division at Anaheim, California. A member of the Beckman organization since 1953, Johnson was manager of systems applications engineering.

Industrial Process Equipment Company, headed by **Peter A. Puleo**, has been appointed representative in the

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For more information, turn to Data Service card, circle No. 153

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SITUATIONS OPEN

SITUATIONS WANTED

A.I.Ch.E. Members

ADMINISTRATIVE CHEMICAL ENGINEER—Age 35, B.Ch.E., with ten years' experience in project, liason, administration, process and mechanical design, sales & production. Available for employment in Mexico or Latin-America. Excellent knowledge of Spanish and Latin-American business procedures. Box 15-11.

CHEMICAL ENGINEER—B.S. Age 32. Family. Completed course work for M.S. Business Management. Over six years' Marketing, Engineering and Development responsibilities in Chemical Industry. Position desired—Market Product Development, Market Evaluation, Technical Service and Sales. Box 16-11.

GRADUATE CHEMICAL & MECHANICAL ENGINEER—Many years' experience, planning, directing development, applied research, process engineering, design of commercial plants, management experience. Fluent French, German. Some Spanish, Swedish. Free to relocate. Box 17-11.

C. P. I. MANAGEMENT—Chemical Engineer available for challenging position. Responsible supervisory experience Development, Manufacturing, Staff. Organic, Inorganic, Polymer, Synthetic fibres, Electrochemicals, Pigments Technology. Preparation, Presentation Technical-Economic Reports. Industry, Government client negotiations. Project Liaison. Box 18-11.

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SITUATIONS WANTED

(continued from page 225)

CHEMICAL ENGINEER—B.S.Ch.E., 1949. Ten years' experience in development and production, including heavy experience in new plant start-up and trouble-shooting. Interested in better opportunity and more responsibility. Box 19-11.

CHEMICAL ENGINEER—B.Ch.E., 1952. Age 29, seven years' experience in production supervision, process engineering, and process development. Ambitious, proven record. Seek challenging position in manufacturing. Type of man that you need in a key position. Prefer 100 mile radius of N. Y. C. Box 20-11.

CHEMICAL ENGINEER—B.S.Ch.E., P.E. Twenty years' experience all phases engineering contracting Process Plants chiefly petroleum industry. Have successfully fulfilled positions of major responsibility. Seeking senior position engineering company or company planning major plant expansion. Box 21-11.

CRYOGENIC ENGINEER—Ph.D. (Ch.E.), P.E., age 26. Four years' experience in Cryogenic Processes research, previous experience in refining and teaching. Seek research or development position in Cryogenics on West Coast. Box 22-11.

PROCESS-PROJECT ENGINEER—B.Ch.E., P.E., age 33. Eleven years' progressive experience (nine with major contractor) in pilot plant studies, process development, process design, economic evaluation, equipment selection, project management. Profit conscious, adaptable manager. Five figure salary. Box 23-11.

CHEMICAL ENGINEER—M.S., 1951, (Honors). Senior process design engineer, seven years' experience in process design and economic evaluation, development, start-up, operations, staff work, labor disputes. Tired of fighting organization men. Want to work for company desiring results and willing to pay for same. Family. Box 24-11.

PROCESS ENGINEER—M.Ch.E. Fifteen years' experience in chemical and polymer process development and process engineering. Line and staff assignments at management levels. Desire similar activity with growing company. Box 25-11.

SEEK TEACHING POSITION—Ph.D. Chemical Engineer, professionally registered, with ten years' diversified industrial and teaching experience, desire professorship in a Western institution. Box 26-11.

M.S. (Ch.E.)—Ten years' diversified experience: R&D, process engineering, trouble-shooting, start-ups, foreign plants, production, publications. Speak German. Desire Technical Director or equivalent in deep south U.S. or foreign. $10,800 minimum. Box 27-11.

PROCESS ENGINEER—Eighteen years' experience in process design, economic analysis, long-range planning, process development, and initial operation of petrochemical plants and oil refineries. Responsible charge of projects for engineering contractors and supervisory experience over plant engineering department for operating company. Desire responsible position with engineering contractor or operating company. Box 28-11.

CHEMICAL ENGINEER—B.Ch.E., age 31, married, veteran. Ten years' experience process development, pilot plant operations, project engineering, field engineering, very strong in plant start-ups, government contracts and specifications. Interested in food, chemical or process equipment manufacturing. Location unlimited. Box 29-11.

REFINERY CHEMICAL ENGINEER — Eleven years' engineering and operating, seven in supervisory. Experience in most phases of modern petroleum refining—design, construction, process operation, maintenance, safety, economics, process and project engineering. Desire engineering position. B.S.Ch.E., 1948. Box 30-11.

CHEMICAL ENGINEER — Seeking responsible position with management potential. Ten years' experience in project planning, pilot plant operations, plant start-up and process improvement, liaison between R&D and manufacturing. Knowledge of batch and continuous operations in petroleum, pharmaceutical, and food fields. M.S. Chemical Engineering, patent applications; age 33, married, veteran. Box 31-11.

CHEMICAL ENGINEER—B.Ch.E., 1944. Fifteen years' experience with engineering construction, and process equipment fabricators for the chemical and petroluem industries. Desire responsible position as process or project engineer Box 32-11.

URANIUM-VANADIUM

MILLING POSITIONS

Mechanical, Chemical and Extractive Metallurgical Engineers and Chemists with good qualifications and 0 to 6 years of experience to work in Colorado Operations. Locations: Rifle and Uravan. Send resume and copy of college transcript to:

Union Carbide Nuclear Company
Division of Union Carbide Corporation
Post Office Box 1049
Grand Junction, Colorado

ENGINEERS

Chemical, Mechanical or Industrial

To train for production supervision, plant trouble-shooting or process engineering. 1-5 years experience. Positions open at various operating locations.

Please send resume in confidence giving age, education, experience and approximate salary to:

Central Personnel Office
Solvay Process Division,
Allied Chemical Corporation
P. O. Box 271,
Syracuse 1, New York

SITUATIONS WANTED

CHEMICAL ENGINEER—B.S.Ch.E., and nine economics courses. Nine years' experience in plant improvement and trouble-shooting: cellophane, chlorine, soda ash and supervision of new equipment start-up. Challenging position in engineering or management. Box 33-11.

CHEMICAL ENGINEER—M.S., 1950, age 31, married. Nine years' experience mainly process design petroleum refining, petrochemicals. Prefer responsible position process design or project evaluation. N. Y. C. Metropolitan area. Consider Middle Atlantic or New England states. Box 34-11.

CHEMICAL ENGINEER—B.S., 28, married, one year experience since graduation, two years' experience during college, all in process development. Upper third of class. Desire position in process development. Box 35-11.

CHEMICAL ENGINEER—M.Ch.E., eleven and one half years' experience in process, project activities including supervisory positions. Experience involved all phases from preliminary process design through detailed engineering to plant start-up on wide variety of chemical, and petrochemical processes, including economic studies, process evaluations, technical coordination of detailed engineering and field work. Prefer company offering professional growth opportunities. Box 36-11.

LATIN AMERICAN ASSIGNMENT—sought by chemical engineer, age 34, family, experienced in manufacture of organic chemicals, synthetic rubber, operations, design. Speak Spanish, familiar with Portuguese., Good scholastic record. Permanent position only. Box 37-11.

TRAVELING OVERSEAS—Graduate chemical engineer, eight years' varied experience, leaving December for one year trip to Japan, Southeast Asia, India, Africa, Europe. Available for technical surveys, business contacts, sales representation, etc. Box 38-11.

CHEMICAL ENGINEER—Ph.D., 37, diversified experience in research, development, production liaison, ore chlorinations, chloride metallurgy, fluid beds, high temperature reactor design, semiconductor research and production, patents, publications. $14,000 range. Box 39-11.

(continued on page 230)

An Invitation To Join ORO . . . Pioneer In Operations Research

Operations Research is a young science, earning recognition rapidly as a significant aid to decision-making. It employs the services of mathematicians, physicists, economists, engineers, political scientists, psychologists, and others working on teams to synthesize all phases of a problem.

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No other Operations Research organization has the broad experience of ORO. Founded in 1948 by Dr. Ellis A. Johnson, pioneer of U. S. Opsearch, ORO's research findings have influenced decision-making on the highest military levels.

ORO's professional atmosphere encourages those with initiative and imagination to broaden their scientific capabilities. For example, staff members are taught to "program" their own material for the Univac computer so that they can use its services at any time they so desire.

ORO starting salaries are competitive with those of industry and other private research organizations. Promotions are based solely on merit. The "fringe" benefits offered are ahead of those given by many companies.

The cultural and historical features which attract visitors to Washington, D. C. are but a short drive from the pleasant Bethesda suburb in which ORO is located. Attractive homes and apartments are within walking distance and readily available in all price ranges. Schools are excellent.

For further information write:
Professional Appointments

OPERATIONS RESEARCH OFFICE

ORO The Johns Hopkins University

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BETHESDA 14, MARYLAND

For more information, turn to Data Service card, circle No. 135

CHEMICAL ENGINEERING TEACHING POSITIONS AVAILABLE

A list of chemical engineering teaching positions in schools and universities in the United States and Canada on Oct. 15, 1959 may be obtained from the Secretary, A.I.Ch.E., 25 West 45th Street, New York. Salary data and rank of position are given.

ADVANCE INFORMATION

The Situations Wanted portion of this Classified Section is preprinted and mailed a few days in advance of publication, to Employment Directors. Send names of individuals who should be on mailing list to: Miss E. Adelhardt, Chemical Engineering Progress, 25 W. 45th Street, New York 36, New York.

SPECIAL NOTICE

Effective July 1, 1959. Members of the American Institute of Chemical Engineers in good standing are allowed TWO sixline Situation Wanted insertions (about 36 words) free of charge per year.

Positions Available

New York Office

CHEMICAL ENGINEERS, CERAMISTS OR CHEMISTS, graduates of recognized schools, for work along research and sales service lines. Up to five years' experience, particularly in the field of cement, heavy ceramics or the stone and lime industries desired. Location, South. W-8051.

RESEARCH ENGINEERS. (a) Research Engineer, Ph.D., chemical or mechanical engineering, 28-40, experienced or trained in heat transfer, thermodynamics or fluid mechanics for work in areas such as thermal radiation, convection, boiling, conduction, flow-induced noise, two-phase flow, multi-component mixing and separation. Will guide research programs, analyze experimental results and consult on advanced engineering problems associated with steam generators, nuclear components and other heat transfer equipment. Salary, $9,600-$11,400 a year. (c) Chemical Engineer, M.S. or Ph.D., 25-35, with experience in experimental research to interpret and correlate results of various experimental R & D programs. Should have broad background in basic science and engineering. Typical projects involve high temperature inorganic chemistry, thermochemical calculations, mass transfer operations and heat transfer from gases by radiation. Salary, $8,900-$10,200 a year. Some travel. Must be U. S. citizens. Company pays placement fees and relocation expenses. Location, Ohio. W-8041.

PROJECT DESIGN ENGINEER, chemical or mechanical engineering graduate, with at least five years' design and layout of pharmaceutical manufacturing plant. Salary open. Duration, one year. Location, Italy. F-8020.

CHEMICAL ENGINEER, B.S. in chemical engineering, with plant design, construction, operating and technical service in ore processing and metallurgical and chemical fields. Salary, $7,500-$9,000 a year. Location, New England. W-8013.

CHEMICAL PROCESSING ENGINEER with five years' experience in the process department of an engineering contractor or oil company engineering department, designing or evaluating fired heaters. Additional experience designing or preparing quotations on fired heaters useful. Salary, about $10,000 a year. Company will negotiate fee. Location, Pennsylvania. W-7953.

FIELD ENGINEER, chemical, mechanical or electrical engineering graduate, young, with process plant engineering experience, to analyze equipment operations and process, prepare reports, make cost surveys and recommend improvements in process, equipment, power or product quality. Traveling and relocation. Salary open. Headquarters, East. W-7933.

ASSISTANT DEVELOPMENT ENGINEER, graduate in chemical or mechanical engineering, or chemistry, with a minimum of two years in product development and follow-through of production. Experience does not necessarily have to be in plastics. Will work on development or prototype products and processes of corrosion resistant plastic piping and accessories. Salary, to start, $6300-7300 a year. Location, Newark, N. J. area. W-7927.

SALES PERSONNEL. (a) Rubber Chemicals Sales Engineer to build sales volume in industrial chemicals for rubber industry. Degree in chemical engineering or chemistry with knowledge of polymerization of G.R.S. rubber. Should have experience in sales to or experience in synthetic rubber making and compounding (wide acquaintance in industry desirable); similar experience in oil industry an asset. Salary, $15,000 a year minimum. Location, New York Metropolitan area. (b) Regional Sales Manager to build regional sales activity in chemicals for textile processing and finishing; 35-45; degree in chemical engineering preferred; with industrial selling plus sales management experience, to the chemical industry, with textile chemicals preferred. Salary, $15,000 a year minimum. Headquarters, North Carolina; territory, The Carolinas and Georgia. W-7921.

CERAMIC PROJECT ENGINEER, B.S. or M.S. in chemical engineering, ceramics or chemistry, with two to five years' experience in research on ceramics and/or graphite for reactors, particularly fuel elements for high-temperature gas-cooled reactors. Salary open. Company will pay placement fee. Location, Ohio. W-7917.

ENGINEERS with five to ten years' experience on process and industrial chemical plant projects. (b) Chemical Engineer for work involving preparation of heat and material balances; preparation of process and engineering flow diagrams, performing basic engineering calculations and designs; sizing equipment pipe lines. Ability to prepare cost estimates, operating expense estimates and comparative economic studies along with supervision of construction drawings desired. (c) Instrumentation Engineer, mechanical or chemical engineering graduate, with experience in the design and specifications of complete control systems for chemical and process plants. Systems are mainly pneumatic. Electronic controls experience desirable but not necessary. Salaries, $8000-$12,000 a year. Location, eastern Pennsylvania. W-7894.

PROCESS ENGINEER, chemical or mechanical graduate, with planning, production and operations supervision in food or allied fields. Salary, $8000-$10,000 a year. Location, New York, N. Y. W-7871.

JUNIOR ENGINEERS interested in project engineering work in a production department, chemical graduate, to handle the maintenance and modification of existing equipment and the recommendations of changes in new equipment for plastics producer. Location, New Jersey. W7727(a).

PRODUCTION MANAGER with mechanical or chemical engineering training and at least five years' supervisory production experience in plastic fields covering compression and transfer molding. Salary, $10,000-$12,000 a year. Location, Connecticut. W-7709.

CHEMICAL ENGINEERS for process development group or pilot plant; fine organic chemicals. (a) Project Engineer, B.S. in chemical engineering, with two to five years' experience. Salary, about $7500 a year. (b) Supervisor to take charge of entire engineering group; will be responsible for pilot plan or process development operation. Five to ten years' experience required. Salary, $9000-$10,000 a year. Location, Orange County, N. Y. W-8094.

Chicago Office

CHEMICAL ENGINEER, graduate, with at least four years' experience in heat transfer and fluid flow calculations as applied to the design of industrial heat transfer equipment. Previous experience with manufacturers of evaporating equipment, heat exchangers or power plant condensers desired, or previous employment doing paper mill design for plant installations will be considered. Salary, to $9000 a year. Employer might negotiate fee. Location, southern Wisconsin. C-7675.

San Francisco Office

RESEARCH ENGINEER, Institute, preferably M.S. in chemical or sanitary engineering, recent graduate, for assisting in conducting routine chemical analyses; six months' summer field work and six months' university laboratory studies. Salary open. Location, Washington. S(P)-4744.

SALES ENGINEER, Equipment, chemical engineering degree preferred, to 40; experience contacting engineering companies and users to provide technical information and sell major items of equipment and machinery for chemical and food industries (evaporators, sprayers, dryers, pulverizers, dust collectors, pumps, belt scales, centrifugals, screws, ice cream packages). For manufacturer's agent. Car required local men only. Salary, $500-$700 a month, plus possible bonus. Location, northern California. S(P)-4616.

RESEARCH ENGINEER, chemical engineer or chemist, 25-35, with two to ten years' experience in plant control and products research and development relating to pulp and paper. Particular interest in experience related to coatings; for paper board manufacturer. Salary commensurate. Location, San Francisco Bay area. S(P)-4729.

RESEARCH COMPUTER ENGINEER, experienced chemical or mechanical engineer, or applied physicist, with good background in mathematics; computer experience desired but not required. Work will consist of analysis and programming of engineering problems for Datatron 205 computer in research division. Apply by letter. Employer will discuss payment of placement fee. Location, southern California. S(P)-4721-R.

SALES ENGINEER, Water Treatment Equipment, preferably chemical engineer or chemist, 25-40 with two to four years' recent sales experience or in closely allied lines, preferably power plant type sales. Will call on industrials to promote use and sale of water softening and treating chemicals and related equipment (feeding, screening, etc.). Prefer experience in California. Salary, $5000 a year plus commission, car allowance, expenses. Location, northern or southern California. S(P)-4716.

PROCESS METHODS ENGINEER, Tronics Components, graduate chemical or electrical, or physicist, with experience in developing improvement and control production process and able to develop statements or production methods and process from research and development data. Experience desired in tronic component field, but not essential. Position with manufacturer of precision, close tolerance, tronic component involving machine shop work, welding, forming, etc. Salary, $550-$650 a month. Relocation costs and placement fee paid. Location, San Francisco Peninsula. S(P)-4587.

For more information, turn to Data Service card, circle No. 137

people in marketing

from page 223

St. Louis, Mo., area by the J. E. Lonergan Company.

Hans Treumann has become technical product manager, American Home Products, Boyle-Midway Division. He was, for six years, chief engineer and chief chemist at U. S. Testing.

William T. McLaughlin promoted to field sales manager, Pittsburgh Coke & Chemical, Protective Coatings Division. He will supervise the division's nationwide sales.

Ellis D. Verink, Jr. named manager of chemical and petroleum industry sales for Alcoa. Verink, head of the sales development division in the chemical section at New Kensington, Pa., since 1948, will move to headquarters in Pittsburgh. Widely known as an expert in corrosion problems, he is author of numerous articles on corrosion prevention, and applications of aluminum in chemical and related industries.

NECROLOGY

Everett Keith McMahon, 39. McMahon was manager of the Chemical Sales Division, Tennessee Products & Chemical (Merritt-Chapman & Scott). A member of the firm since 1949, he was well-known as a lecturer before student groups on the subjects of chemical engineering and market research.

Exclusive license to manufacture dimethyl sulfoxide in the U.S. and Canada by a process owned by a Swedish firm has been secured by Crown Zellerbach. The process consists of a liquid phase oxidation of dimethyl sulfide using air or oxygen in the presence of nitrogen as catalyst. Crown Zellerbach enters the DMSO picture with a chemical complex near their paper mill at Bogalusa, Louisiana. Start-up of the 5 million pounds annual capacity unit is expected for early 1960. To supply the DMSO plant, a 10 million pound a year dimethyl sulfide facility will be built nearby.

Additives for petroleum products will be manufactured and marketed by a newly formed company in the European market, Amoco Fina. Jointly owned by Amoco Chemicals and Petrofina S.A., Brussels, Belgium, the firm is constructing a plant at Antwerp which is due to start production early in 1961.

SITUATIONS WANTED

continued from page 227

B.S.Ch.E.—plus graduate studies. Age 33, family, veteran, located in east. Ten years' diversified experience in chemical, mechanical, and nuclear engineering development and design. Minimum salary $860.00 per month. Box 40-11.

VICTIM OF MERGER OFFERS — Thirty-one years' of diversified production, process development, design, administrative and consulting experience, principally in paper, food and agricultural chemicals. Box 41-11.

CHEMICAL ENGINEER — P.E., B.S., M.Ch.E., MBA June 1960. Six years' R&D, plus two years' design and economic evaluations, in petroleum and petrochemicals. Management oriented. Age 30. Box 42-11.

ENGINEER — B.S. '50. Age 33, Q Clearance. Nine years' experience production supervision, process engineering, process design. Extensive experience in plant start-ups and process modification and improvement. Western United States preferred. Box 43-11.

CHEMICAL ENGINEER—B.Ch.E. 1951, M.Ch.E. 1955, licensed P. E., N. Y. State. Eight years' experience process design and project engineering petroleum refining and petrochemical units. Seeking challenging growth opportunity in New York metropolitan area. Veteran, single, age 32. Box 44-11.

For more information, circle No. 145

A Preprint of all SITUATIONS WANTED notices is mailed directly monthly to thousands of personnel and recruitment officers nationally.

CLASSIFIED SECTION RATES

Advertisements in the Classified Section are payable in advance at 24c a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. **Members of the American Institute of Chemical Engineers in good standing are allowed two six-line Situation Wanted insertions (about 36 words each), free of charge a year. Members may enter more than two insertions at half rates.** Prospective employers and employees in using the Classified Section generally agree that all communications should be acknowledged as a matter of courtesy but recognize circumstances where secrecy must be maintained. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 15th of the month preceding publication.

Classified . . .
EQUIPMENT SECTION

INDEX OF ADVERTISERS

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News and Notes of A.I.Ch.E.

Local Section activities—In line with the report last month on Local Section activities, one of the other projects of the Chicago Section is allocation of section funds to purchase A.I.Ch.E. publications for the John Crerar Library. This is an activity that many Local Sections engage in—purchasing guidance books, etc., from A.I.Ch.E. for their local library. Chicago too, as many of our members already know, presents the Harry McCormack Award to outstanding students of the senior class in chemical engineering at the Illinois Institute of Technology and at the Northwestern Technological Institute. The award is named in honor of a charter member of the section and a long-time chairman of the Department of Chemical Engineering at Illinois Institute of Technology. **East Texas Section** now has a Council liaison member, John J.

McKetta. **Baltimore, Md., Section,** according to Philip Messina, secretary of the group, began its fall season by taking several important professional steps. It allocated a sum of money to support the Committee on Guidance for Maryland, the sole purpose of which is to stimulate engineering interest among young people, and it also approved distribution of the *Baltimore Engineer* to all its members. Their meeting announcement is decorated with cartoons which add to the readability.

Council activities—At St. Paul, Council spent all day Saturday on a lengthy business agenda. Some of the actions taken will have far-reaching effects not only on our profession of chemical engineering but on engineering as a whole. Thumbnailed here are a few of the actions taken. Council agreed to support a proposed **Engineers Joint Council Newsletter,** still very much in the talking and formative stage. The idea is that Engineers Joint Council will try to create a newsy, informative, quickly read publication to go to all the members of the affiliated engineering societies. This was approved by Council as a vital step for the future of E.J.C. **Model law**—B. B. Kuist, C. E. McCulloch, and J. J. Healy—the last named the Council liaison to the Professional Legislation Committee, the first two the chairman of the committee and a long-time member of it —had a lengthy and fruitful discussion with Council on a proposed revision of the Model Engineering Registration Law, which A.I.Ch.E. accepted in 1946, and the committee was instructed to bend its best efforts to make certain that the use of the term *engineer* by all those who are qualified to be engineers and who have used it historically is not denied them in any provision of the model law. Also the committee is to try to include in the model law a provision for the performance of engineering work by employees of corporations engaged in manufacturing, research, or development operations. The old grandfather clause, proposed to be dropped from the new revision on the theory that all states now have registraton laws, ought, Council thought, to be retained as a necessary protection for those who are legally practicing but are not registered at the time when a more stringent law is passed. **New testing procedure**—W. R. Collings, Council liaison member for the Equipment Testing Procedures Committee, presented a new Standard Testing Procedure on dryers, the work of a subcommittee headed by J. P. Wilson, and this will be soon published by A.I.Ch.E. **Founders Award for 1959**—Preliminary screening by the Awards Committee and then by a special Founders Award Committee of Council, plus a ballot by Council, selected as Founders Award winners for 1959 Francis J. Curtis, a former president of A.I.Ch.E., and W. H. McAdams, Professor of Chemical Engineering at MIT. These awards will be made at the Awards Banquet in San Francisco. **By-laws revision**—H. F. Nolting, Chairman of the Constitution and By-laws Committee, brought in a half dozen changes necessary in the by-laws owing mostly to changes in the make-up of A.I.Ch.E. These were expeditiously passed. The philosophy of **chemical engineering accreditation** was presented by Carl C. Monrad, chairman of the Institute committee in charge of accreditation. He discussed with Council the recommendations of his committee which had been passed on to Council in June and July for consideration, all this in preparation for the October meeting of the Engineers' Council for Professional Development. **Election ballot format** was presented by the Secretary for Council's approval. By the time this appears, all members will have received the ballot. Finally, reports on the **Machine Computation Committee** and the **Heat Transfer Division** were presented by R. P. Genereaux, who is Council liaison for both.

That's not all. These were only Council actions. Each member should know, however, that for every definite action, Council and the Executive Committee spend many hours in looking at A.I.Ch.E. operations. Just recently a study was made of the posting of the election of members in *Chemical Engineering Progress* after they have been passed by the Admissions Committee but before their approval by Council. An extensive study was made, too, on the time lapse between application and election, and it was agreed that the record is reasonably good and that the Secretary's office be encouraged to continue several procedures recently instituted for speeding up consideration of applications.

Annual Report—Incidentally, Council added to the budget a sum for the purpose of making the annual report available to all members. Therefore

the 1959 report, which is being written by Professor R. H. Wilhelm, of Princeton, will be mailed to you as soon as it is published.

Committee on Dynamic Objectives —R. R. White of the University of Michigan called the first meeting of the Committee on Dynamic Objectives at St. Paul and made assignments, on a geographical basis, for report at San Francisco. There will be an open meeting at San Francisco for discussion of this project by everyone interested. There is an item on this committee on page 204 of C.E.P.

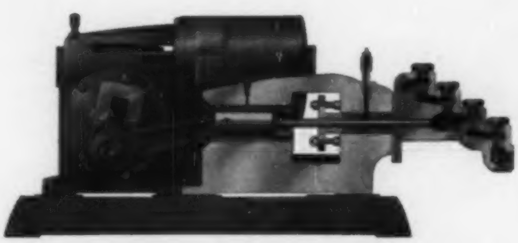
F. J. V. A.

HOW TO METER SLURRIES ACCURATELY

Few pumping jobs present more complex problems than the accurate metering of slurries. Since they are often abrasive, slurries can make the selection of pump parts extremely difficult. Minute particles settling out in the packing can score a plunger beyond usefulness in minutes. And viscous, tacky slurries can limit ball check freedom and reduce accuracy. But even the toughest slurries *can* be metered accurately . . . by adhering to good slurry handling practice, and by choosing the right pump for the job.

Keep Slurries In Suspension

Several practices that have proved valuable in this difficult service are aimed at keeping the solids in suspension. Suction and discharge lines should be as short as possible. The supply tank should always be well agitated. And if packed plunger pumps are used, stroking speed should be held between 45 and 75 rpm to minimize settling.



Standard Motor Driven Controlled Volume Pump

Choosing The Right Pump

Controlled volume pumps are manufactured in a sufficient variety of designs to provide a full range of desired characteristics for slurry service. An economy pump such as Milton Roy's H20® can handle slurries up to 5% by weight. Standard motor driven pumps, with minor modification, can handle much denser slurries. And the new ODS (Oliver Diaphragm Slurry*) controlled volume pump can easily manage slurries containing up to 60% solids by weight.

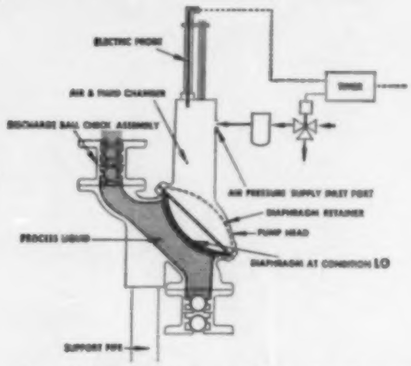
*Manufactured under exclusive license granted by Dorr-Oliver Inc.

Packed Plunger Pumps

Because the entire liquid end of a packed plunger pump is in intimate contact with the slurry, considerable attention must be paid to materials selection. Ball checks and plunger should be as hard as possible, and seats should be relatively soft. Balls are usually made of Hastelloy D, 440 stainless, or ceramic, while 316 stainless is standard for the seats. The plunger must be extremely hard, and high strength sintered alumina is generally recommended.

Proper packing maintenance in slurry service demands that packing be flushed out continuously. An internal flush, continuously bleeding a small amount of liquid along the plunger, is the most common. Dangerous liquids may require an external flush arrangement. Liquid is continuously fed in on one side of the lantern ring, drawn around the plunger, and carried away from the other side.

The ODS Controlled Volume Pump



Capable of pumping 180 gph of the densest slurries at accuracies of ± 2% against pressures up to 90 psi, the ODS has no plunger, no packing. It is based on the Oliver Diaphragm Slurry pump design principle which consists of two opposed chambers separated by a slack diaphragm. A three-way solenoid alternately pressurizes and bleeds air from the upper chamber. With the upper chamber at atmospheric pressure, the suction head forces slurry into the lower chamber. Then, when the upper chamber is pressurized, the diaphragm forces the slurry out through the specially designed ball check valves.

Problem Slurries

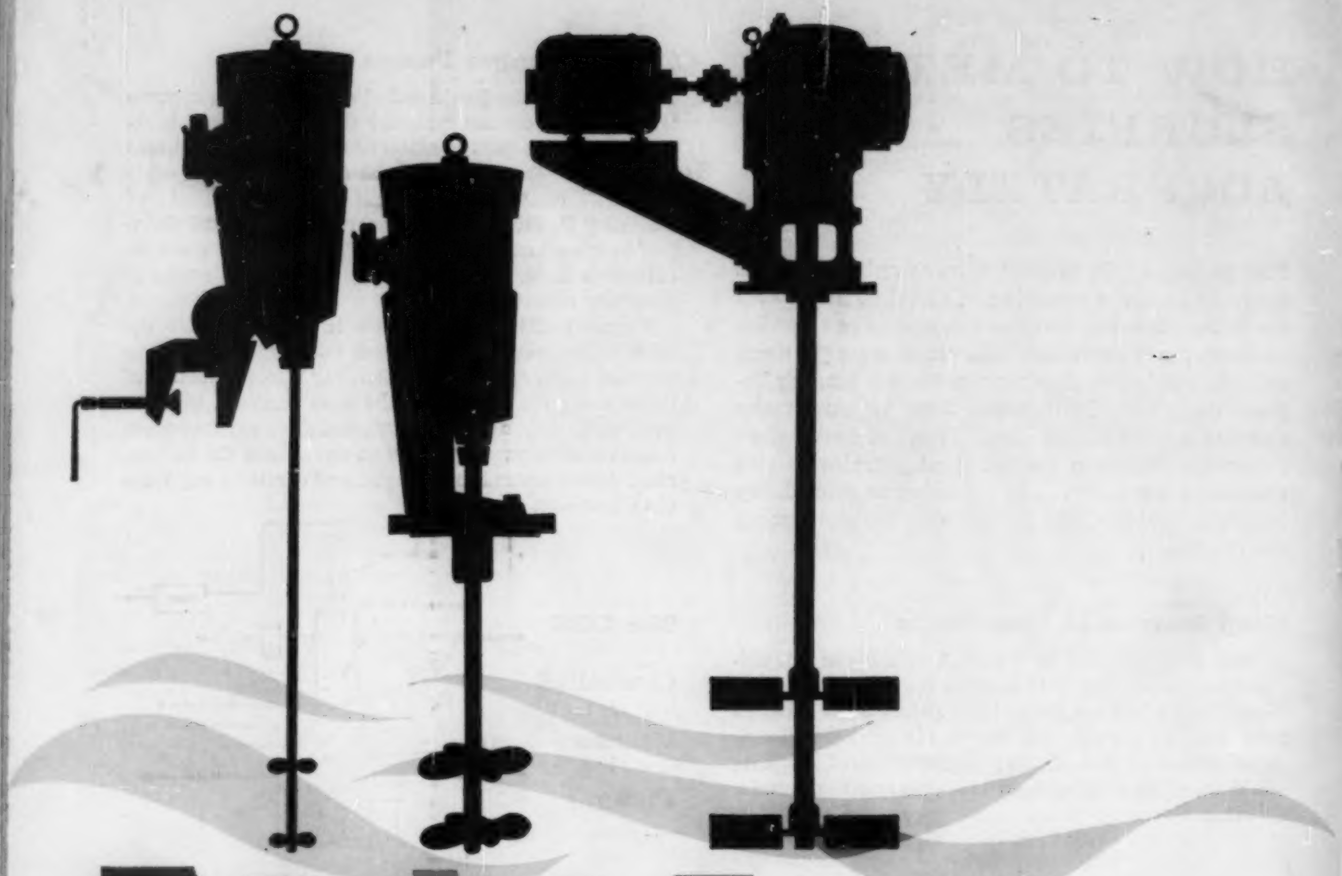
Yes, slurries *can* be metered accurately. And the best proof of this claim is the thousand or more Milton Roy pumps successfully metering slurries in the field. The list includes such problem liquids as an 80% coal slurry, a 45% suspension of lead peroxide in butyl phthalate, 15 to 20% diatomaceous earth slurries, finely divided nickel catalytic suspensions, gold ore slurries, and even a 55% by weight powdered aluminum suspension. Some of these materials are so thick that they can support the weight of a screwdriver.

If precision metering of slurries is one of your problems, look again to Milton Roy's 25 years of experience for your most economical solutions. Write for a general introduction to controlled volume pumping given in Catalog 553-1, Milton Roy Company, 1300 East Mermaid Lane, Phila. 18, Pa.

milton Roy
CHEMICAL INSTRUMENTATION SYSTEMS

Controlled Volume Pumps • Quantichem Analyzers • Chemical Feed Systems

For more information, turn to Data Service card, circle No. 42



NEW

FROM MIXCO
3 WAYS TO GET MORE FLUID MIXING FOR YOUR MONEY

What's new in fluid mixing? Plenty!

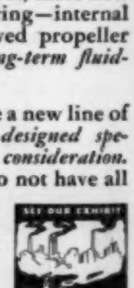
Your first chance to see it for yourself will be at the New York Chem Show, opening November 30.

Here's a preview of ideas from MIXCO that can help you *get more* from your fluid-mixing operations. More productivity. Longer equipment life. Lower mixing cost. And—yes—*lower first cost.*

1. New concept in portable mixing. There's a new look in portable mixers . . . a simple, smooth, rugged outline that promises more performance, better economy than ever. Some of the features you will see in this LIGHTNIN Portable are new speeds, a unique positive-drive chuck and a new clamping and positioning arrangement.

2. New fixed-mounting mixers. Many of the same innovations have been carried over into the full line of LIGHTNIN Fixed Mounting Propeller Types. Inside and out, these new mixers embody the most advanced engineering—internal gearing, new chucking arrangement, improved propeller design—all *centered 100% on cutting your long-term fluid-mixing cost.*

3. New economy for big mixing jobs. You'll see a new line of turbine-type LIGHTNIN Mixers—Series RE—*designed specifically for jobs in which cost is a paramount consideration.* These mixers are precision engineered, but do not have all the protective features of the regular Series E line. They can save you money on mixing operations where the full scale of protective features is not required.



You'll want the whole story on these exciting new developments. So join us at MIXCO Booth 146.

Lightnin® Mixers
MIXCO fluid mixing specialists

MIXING EQUIPMENT Co., Inc., 199-m Mt. Read Blvd., Rochester 3, N.Y.
In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Ave., Toronto 19, Ont.

For more information, turn to Data Service card, circle No. 53